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ENGINEERING APPLICATIONS OF THE GYROSCOPE.[1]

BY

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THE general phenomenon of a freely suspended rotating body, or gyroscope, has been very much obscured by its mathematical friends. Volume after volume of mathematical deductions have been compiled in an attempt to investigate and analyze the numerous gyroscopic reactions and their various ramifications. This interminable labyrinth of formulæ has given the world the impression that the phenomenon of freely suspended rotating bodies is so intertwined with theory as to be of little practical value. I am sure you will agree with me that this is very far from the truth when I have explained to what excellent uses it is possible to put these reactions.

The French scientist Foucault was the first to deduce any practical laws covering the reactions of the gyroscope. This he did in the year 1851, when he astonished the scientific world by demonstrating that the inertia of a rapidly rotating wheel was relative to space, and that the rotation of the earth could consequently be shown by this means.

Lieutenant-Commander Obry, an Austrian naval officer,

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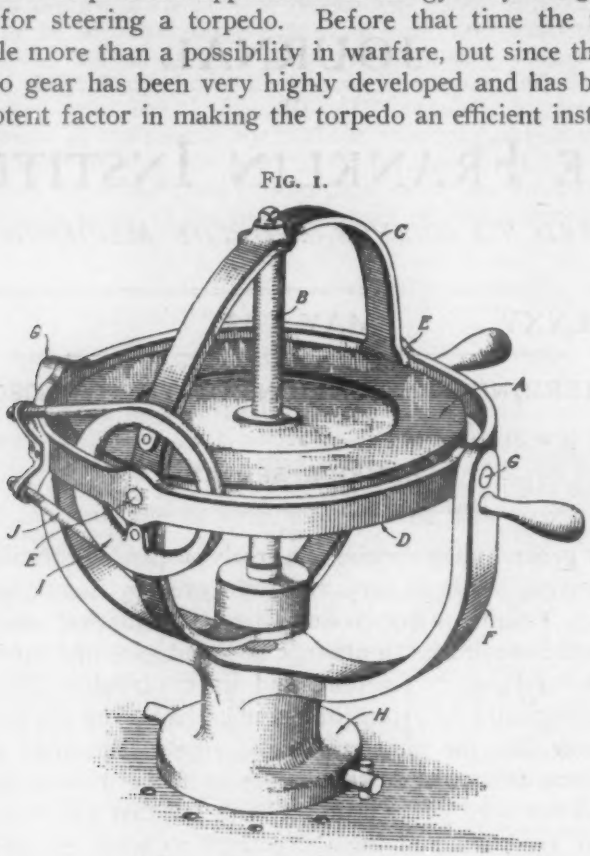
made the first practical application of the gyro by using it as a means for steering a torpedo. Before that time the torpedo was little more than a possibility in warfare, but since that time the gyro gear has been very highly developed and has been the most potent factor in making the torpedo an efficient instrument of war.

FIG. 1.



A simple gyroscope.

Although the many mathematicians who worked over the phenomena became involved in endless abstraction, the phenomenon is, nevertheless, very simple, and the engineering calculations necessary to its practical application are perfectly concrete and easily followed. The phenomenon can be clearly understood by referring to Fig. 1, which is a gyroscope suspended with three degrees of freedom; *i.e.*, freedom about its axis of rotation; *B*, freedom about the axis *G*—*G* and freedom about the axis *E*—*E*.

If the band *J* be securely clamped about the ring *I*, attached to the ring *C*, freedom about the axis *EE* would be suppressed

and the gyro would then be said to have a suspension with "two degrees of freedom."

Suppose the clamp *J* in Fig. 1 is released and the wheel *A* is rotating rapidly, with the side nearest the observer moving from right to left. If a force be impressed on the near side of ring *D*, tending to push that side downward about the axis *GG*, this force will be resisted and movement of the gyro will take place about the axis *E*, *E*, the top of ring *C* and axle *B* moving toward the left. Movement of the gyro is thus seen to take place at right angles to the impressed force. This movement normal to the impressed force is called "precession."

Throughout the study of any gyroscopic apparatus it must be remembered that movement of the gyroscope does not take place in the direction of the impressed force, but that this tendency to move is transferred 90 degrees in the direction of rotation before it is manifested as motion.

Nothing but force caused by angular motion is resisted or causes precession; this angular motion may be about an axis within the gyro or remote from it, but must be angular motion. If linear motion be impressed, no gyroscopic reaction will result, even though the force so impressed be of large magnitude. As angular motion approaches linear motion,—*i.e.*, as its radius of action is increased,—the less will be its gyroscopic effect.

If the precessional ring *C*, Fig. 1, be clamped to the ring *D* so that precession is not allowed, then forces impressed on the ring *D* will not be resisted, even though they be due to angular motion, thus showing that precession must be allowed or the gyroscope will not have the property of resisting forces impressed upon it. It is for this reason that fly-wheels and turbine wheels have no real gyroscopic effect, precession being suppressed by the bearings in which the shaft is held.

All these reactions are due to manifestations of the laws of inertia. The relations between them are expressed by the following equation:

$$M = \frac{WK^2N\omega}{307}$$

M = The gyroscopic moment in pound feet.
W = Weight of the spinning mass.
K^2 = Radius of gyration.
N = Speed of the spinning mass in revolutions per minute.
ω = Velocity of precession, or angular velocity of tilt of the mass about any axis normal to the spinning axis in units of angular velocity or radians per second.

The relation of the various elements of the phenomenon,—namely, (1) direction of spin of rotating the body, (2) the direction of the impressed force, and (3) the direction of the resulting precession,—may be best remembered by comparing with some known and easily recognizable phenomenon. In all probability the child's hoop gives the best clue to these relations. When as youngsters we rolled the hoop we supposed that we were steering it when we beat the hoop at its top upon one side or the other; the facts are we were not steering the hoop at all, but we were impressing a stress upon the hoop, about a horizontal axis, and true gyroscopic action turned the hoop about the vertical axis and changed its direction, thus doing the steering, although we were entirely ignorant of this fact. But it is through this fact that the toy gives us the clue we seek, inasmuch as it involves no feat of memory to correlate the three elements: first, the direction of its rotation cannot be questioned when we are following the hoop; second, there can be no question as to which side of the hoop at the top we beat with the stick which we hold in our hand as we run along back of the hoop or beside it; and, third, there is no question which way the hoop turns when it is so struck. When we beat the top over to the right, precession turns the front of the hoop to the right, and when we beat the top to the left, precession turns the forward point of the hoop to the left. And so here we have a very simple method of remembering this phenomenon, involving all its three elements in their true correlation. The force we impressed about the horizontal axis of the hoop was transferred 90 degrees in the direction of rotation and there manifested as the motion which turned the hoop about its vertical axis.

Among the first attempts at engineering applications of the gyroscope, we find many efforts which have as their object the stabilizing of unstable bodies. The most important of these efforts have been directed toward stabilizing ships at sea. A ship is in effect a pendulum, and is for that reason subject to oscillation when acted upon by the force of waves, which cause it to roll and pitch in the manner with which we are all familiar.

German naval architects have damped the oscillations of this ship-pendulum by interposing on it a second pendulum in the form of so-called anti-rolling tanks. Many of us remember, from our experiences in the physical laboratory, that if we interpose a small pendulum on the arm of a large pendulum, the

small pendulum will act in such manner as to damp the oscillations of the large pendulum, but only when acting in exact resonance with it and lagging 90 degrees in phase. This is exactly the principle of the anti-rolling tanks. The water in these tanks acts as a secondary pendulum which is calculated to oscillate in resonance with the ship but opposed to it in phase. From experiments in the physical laboratory, however, we know that considerable movement of the large pendulum must be set up before the small pendulum begins its oscillations or has any effect, and that if the period of the large pendulum be changed, or if the impulses which cause it to oscillate be changed, the small pendulum must stop and start over again. Briefly, this has been the trouble with the anti-rolling tanks. They have been at best a means for fractional damping of the roll only, and even this damping has been greatly handicapped by the fact that the impulses given the ship by the sea are totally irregular.

The most prominent workers in the field have been Sir Phillip Watt, Professor Biles, and the elder Freud in England, and, in Germany, Herr Frahm. The prominent scientist, Dr. Schlick, made several attempts to use part of the phenomenon of the gyroscope for stabilizing ships. A pendulous gyro was suspended in a ship with freedom of movement about its axis of rotation, which was vertical, and about its axis of precession, which was athwartship. This is called the "passive" type of gyro, and its application is beset with the same difficulties as the anti-rolling tanks; that is, a considerable movement of the ship must set in before the gyro has any effect.

Most of the advantages which would come to the maritime world by using a device for stabilizing ships are quite obvious. Briefly, they may be summarized as follows:

ADVANTAGES COMMON TO ALL SEAGOING SHIPS.

(*A*) Saving in power and consequent saving in fuel owing to the ability to maintain the shortest course between two points in bad weather, inasmuch as the ship will be in no danger from excessive rolling even when steaming in the trough of the sea.

(*B*) Saving in power and consequent saving in fuel owing to the fact that the wetted surface is not increased by wallowing, inasmuch as the vessel is always held on an even keel.

(*C*) Saving in power and consequent saving in fuel by elimination of rolling against the relatively stiff water when under

way. This increase in the power required to drive a vessel which is rolling is due to what is known as the keel or form line impingement. It is illustrated by the far shorter extinction curve of the roll of the vessel when steaming than when not under way.

(*D*) Saving in power and consequent saving in fuel by reducing the yawing and tendency to follow a sinuous course.

(*E*) Saving in fuel and weight by the elimination of bilge keels.

(*F*) Making small ships as comfortable for passengers as large ships, while at the same time being able to prevent the largest from rolling.

(*G*) Eliminating stresses in the structure of the ship and the stresses in the accessories and auxiliaries contained within the ship, which are caused by excessive rolling.

(*H*) Preventing deterioration in cargo caused by excessive rolling. This would particularly apply to ships carrying live stock as cargo.

(*I*) Ability to roll the ship artificially for the purpose of freeing from or rolling off sand or mud banks by opening the contacting crevices and gradually liquefying the encumbent mass.

(*J*) Making a ship more seaworthy by preventing the shipping of seas due to rolling.

(*K*) Vastly increasing the efficiency, certainty, and range of usefulness of ice-breakers,—in fact, opening up a whole new field of operations for this important class of ship.

ADVANTAGES APPLYING ESPECIALLY TO MEN-OF-WAR.

(*A*) Decreasing the amount of underwater armor, which it is necessary to place on men-of-war at present in order to protect that portion of the hull which might be exposed to the enemy by rolling.

(*B*) Steady gun platform.

(*C*) Ability to go into action in any state of sea or upon any course in rough weather.

(*D*) Improving the condition of men and officers by eliminating the fatiguing and other effects of incessant and constant rolling.

(*E*) Ability to roll the ship artificially to standard angles as desired, in competitive target practice.

Very early in the work of stabilizing ships Sir John I. Thornycroft gave it as his opinion that ships could never be

stabilized by means of the so-called "secondary resonance" phenomenon of the anti-rolling tanks, inasmuch as any device for efficiently quenching roll must deal with each impulse from the sea as it arises. To accomplish this he designed an anti-rolling pendulum hydraulically controlled to shift the centre of gravity of the ship so as to counteract each tendency to roll as it occurred. This device worked perfectly up to the breaking-down point of the couple so established.

A characteristic roll curve such as that shown in Fig. 2 will

FIG. 2.

Characteristic roll curve.

show that the roll is due to an accession of small impulses from the sea, and, if the ship is to be effectually stabilized, each of these small impulses must be counteracted as they occur.

This is the principle on which the active type of gyro operates. In the application made on the U. S. S. *Worden* the gyros are mounted with their axes horizontal and normally athwartship and with their precession rings pivoted about the vertical axis. Movements about the vertical axis are controlled by an engine called the precession engine (see Fig. 9); this engine is in turn controlled in any one of several ways, for instance, by a

small gyroscopic pendulum which maintains a fixed base line. A tendency to roll, of even so small an amount as 1/10 of a degree, is immediately felt by gyro pendulum, which accordingly controls the precession engine and causes it to move the gyros in such a manner as to deliver an impulse to the ship about its longitudinal axis which will exactly counteract the tendency to roll. This efficiently prevents any motion, and, as the ship is kept on an even keel, very little power is required to accomplish this. It efficiently performs the requirements set down by Sir John I. Thornycroft when he says that " the perfect stabilizer must act against the forces which are acting on the ship in such a way as to always resist the effect of the sea in producing motion."

Fig. 7 is a photograph of one of the *Worden* gyros, showing the wheel casing, the induction motor (lower left) which spins the wheel through a friction drive, the vertical precession ring, and the self-oiling bearings.

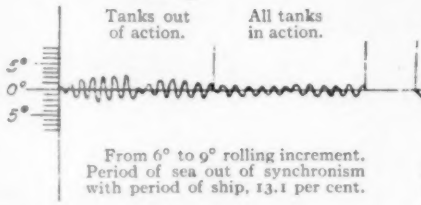
COMPARISON—DAMPING TANKS AND EQUIVALENT GYRO STABILIZING PLANT, S. S. ASHTABULA.

Period of roll	Notes	Weights in metric tons			Percentage of displacement	Space required		Capacity for rolling ships
		Water	Tanks	Total				
TANKS.								
						Cu.mtrs.	*Cu. ft.*	
6 Sec.....	Two tanks 60 feet and 40 feet long	784	95	807	19.8	960	33,180	None
6.6 Sec.....	Two tanks 40 feet and 20 feet long	490	65	555	12.4	626	21,600	None
COMPLETE GYRO EQUIPMENT.								
Any period..	One plant.....	0	0	51	1.1	64	2,200	Through an arc of 8° to 10°

The gyro constitutes an ideal apparatus for this work, inasmuch as it is perfectly safe. It is unnecessary to run the wheel at any but comparatively low stresses. In fact, the stresses present can be brought below those used in hull practice. The comparatively slow motion of the wheel is very inexpensive to develop and maintain, representing only a small fraction of the power required to propel bilge keels; and this power, small as it is, is only required when the necessity for stabilizing arises,

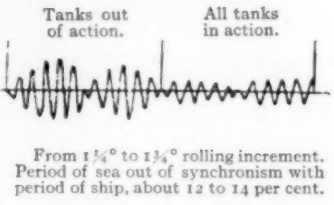
and then only in proportion to the seas running at the time; whereas the power required to drive the bilge keels is a constant drag in all weathers. The power for controlling precession is trifling,—only sufficient to absolutely control and limit the precession movements at all times. This arises from the fact that in stabilizing the constant tendency of the ship is to do precession-wise work upon the gyro. This is fully borne out in prac-

FIG. 3.



From 6° to 9° rolling increment. Period of sea out of synchronism with period of ship, 13.1 per cent.

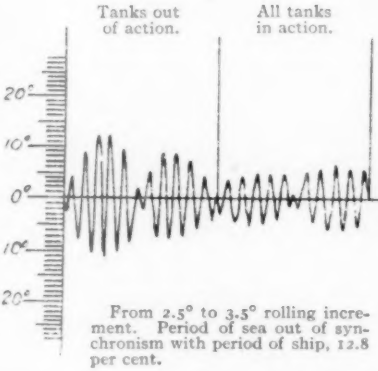
FIG. 4.



From 1¼° to 1¾° rolling increment. Period of sea out of synchronism with period of ship, about 12 to 14 per cent.

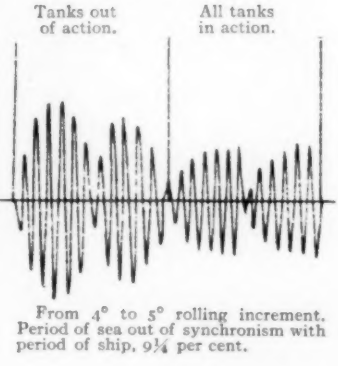
tice, as it is found that the power required for the precession engine is almost *nil*, it being sufficient to control the implacement of the positive and negative energizations delivered to the ship. The gyroscope is ideal in another sense, for with it we have the weight of Thornycroft greatly augmented as to mass

FIG. 5.



From 2.5° to 3.5° rolling increment. Period of sea out of synchronism with period of ship, 12.8 per cent.

FIG. 6.



From 4° to 5° rolling increment. Period of sea out of synchronism with period of ship, 9¾ per cent.

moment by the simple fact that it is in rotation which constitutes a multiplier of tremendous magnitude, even though the actual rotative speed is comparatively low.

That Thornycroft was correct in his line of attack on this problem has now received emphatic confirmation. The effectiveness and mass moment of his weight have been mightily aug-

mented on one hand, while on the other its gravity load upon the ship has been decreased and at the same time the position of its centre of gravity is never shifted. If all these things had originally been in the hands of our distinguished contemporary it is impossible to predict the very great advance that the art of stabilizing ships would by this time have achieved, as only last year he stated: "I came to the conclusion twenty years ago that it was possible to make ships perfectly steady."

In connection with dealing with each individual increment, let us for a moment again refer to Fig. 2. As we trace the envelope of these curves in their rise and fall we note near the centre line where the phase is usually shifted there is always the first impulse of a new cycle, the one which starts the cycle. Now if no cycle of rolling ensued we would have simply a succession of these beginnings, which would naturally be of various signs and magnitudes. These are more numerous in a vigorous, choppy sea, where, as stated, the cycles themselves are shorter and the individuals which shift the periods appear oftener. Now if each of these beginnings could be efficiently suppressed neither the cycles nor the individual rolling constituting these cycles would ever come into evidence, and it is just this suppression that we are enabled to effect by the active type of gyro.

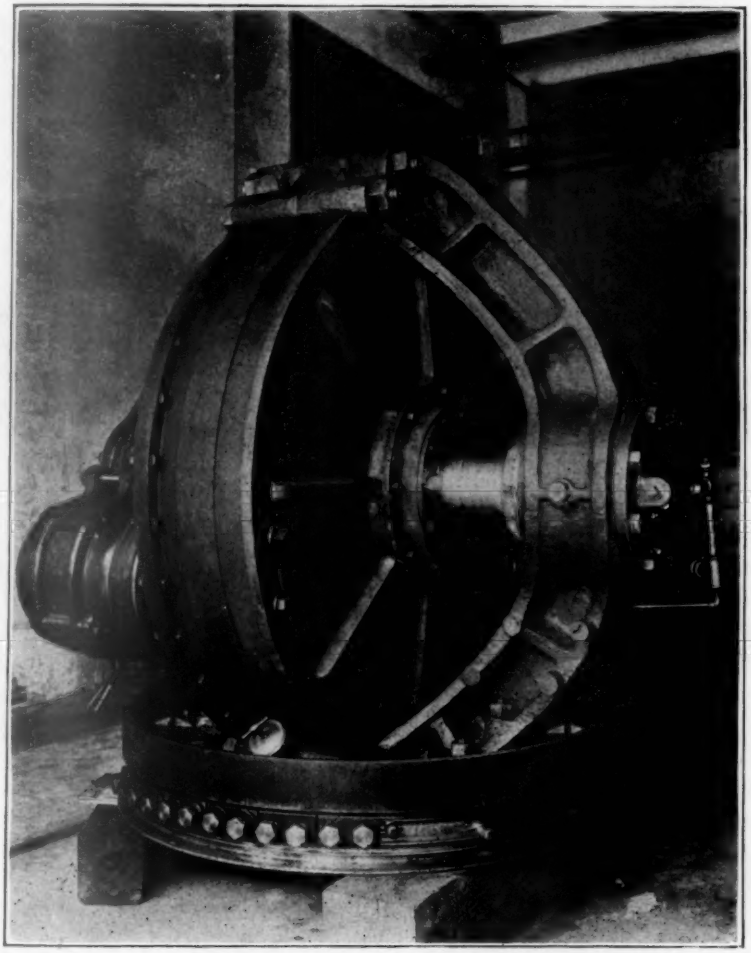
Calculations dealing with known tank equipment well illustrate the powers of the active gyro stabilizer. Let us take the case of Figs. 3 to 6, where only a comparatively small fraction of the roll was dampened, owing to the sea being out of synchronism even by but a slight percentage. The active equipment, as we have seen, is different. It most promptly deals with each momentary energization and "has no memory"; it cares not when nor from what direction the previous stress attack the ship.

The surprisingly small magnitude of the whole gyro equipment is due largely to its unique method of operation; that is, it makes up in activity and promptness what it may seem to lack in size and weight.

This small space is practically independent of location. It need not occupy the most valuable amidships space nor extend entirely across the ship at a point of greatest beam. It may even be divided up in two smaller spaces and be stowed away at any point selected by the designer. In this way the small space required may be that which is least valuable in the whole ship.

Again, the gyroscopic plant is entirely independent of the height component of location, as it is found to operate equally well in the lowest part of the ship and is entirely independent of sym-

FIG. 7.



One of the active gyros of the *Worden*.

metry as to disposition in relation to the ship's centre of oscillation. The gyro precessions being under individual control, each is rendered effective with full force. This persistent and incessant action always in the right direction, not waiting for the

period, but working more rapidly than the period, constitutes another explanation of the smallness of the necessary plant. In modern ships of low metacentric height it is found that the active gyro equipment will represent only a fraction of one per cent. of the displacement.

Another great advantage of the active type of stabilizing gyro, and the advantage that led to the design of this gyro for the *Ashtabula,* arises from the fact that it can be used to produce roll and so cause a ship to break through the ice or enable it to roll off a sand or mud bank.

The gyro employed only requires to be run at one-third or one-half speed for the production of all the rolling that could ever be required by the *Ashtabula* in breaking through the heaviest ice. This is owing to its incessant action developing its full force in proper direction and with the proper emplacement upon each half period. Very heavy rolling can easily be produced and maintained. The action under these conditions is far simpler than in preventing roll, inasmuch as the reaction of the ship, after rolling, is found to react back to the gyro sufficiently to automatically control its precessional movements.

The discussion of stabilized ships reminds me of an amusing incident which occurred at the navy yard in Washington during experiments preliminary to installing a plant on the U. S. S. *Worden.* These experiments were being made with models to simulate a ship, and it had been shown that the principle of the active type of gyro would enable us to do exactly what we had claimed we could do. After the experiments were over an old bluejacket who had been helping us asked me what it was all about, and I told him that the experiments just completed proved that we could prevent ships from rolling. He turned to me and in a very disgusted manner told me that if I had ever been to sea I would know that it was foolish to try to do anything of the sort. "Why," he said, "when you get out there in the middle of the ocean what have you got to hang on to to hold her?" He was right. You do have to have something to "hang on to." And that something must be very powerful. In the case of the stabilizing gyros it is the tremendously augmented inertia of the rotating mass.

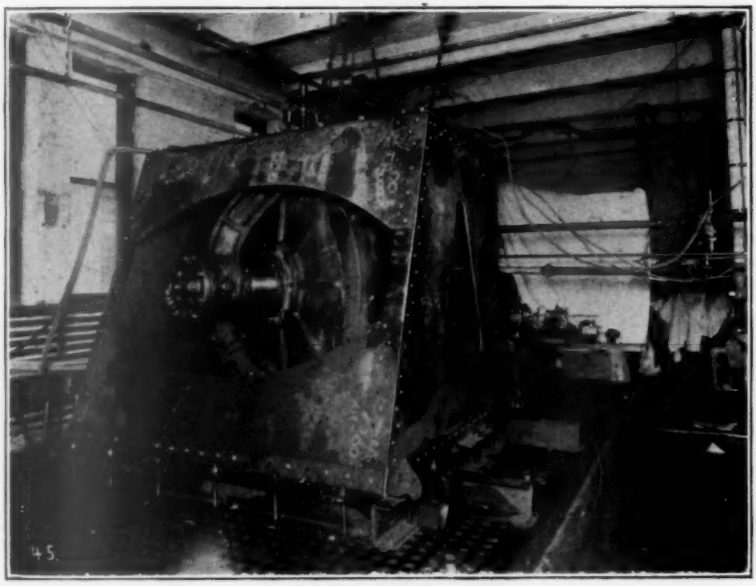
I recently had the honor of presenting a paper before the Society of Naval Architects and Marine Engineers, and after

this paper had been read I was told by the well-known engineer, Mr. W. L. R. Emmet, that the performance of the active gyros in preventing roll of ships described in my paper reminded him of those lines of Kipling:

> I'm the prophet of the utterly absurd,
> Of the patently impossible and vain;
> And when the thing that couldn't has occurred,
> Give me time to change my leg and go again.

So far from being "patently impossible and vain," the results thus far actually achieved have been obtained by machinery

FIG. 8.



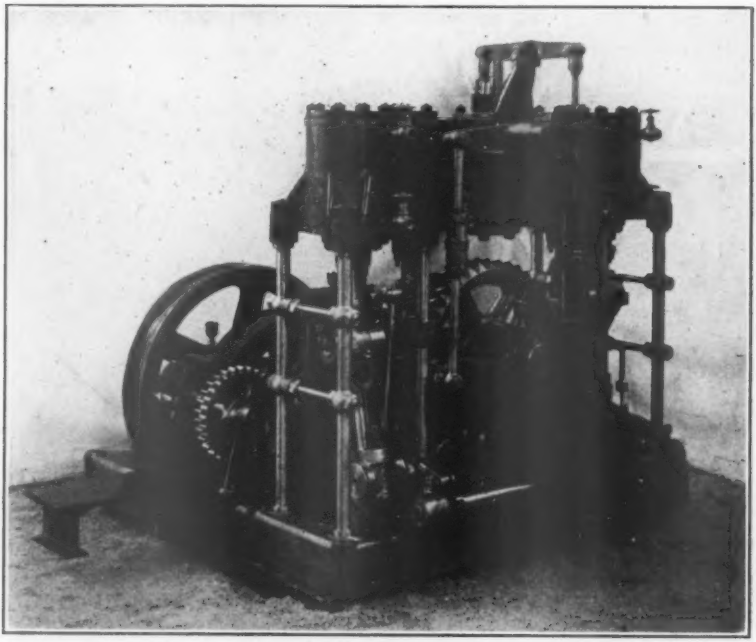
One of the active gyros in the tower during shore trials.

which though unusual is in fact of the simplest character. The installation was found to perform its function so naturally and with such apparent ease as to leave little to be desired as to method. This I believe to be parallel with what has often occurred in the past, that the problem that seems the most insurmountable, like Achilles, has a vulnerable point, and in fact the "thing that couldn't" has been found very simple of solution after it has been fully analyzed and when attacked from the proper angle.

Fig. 8 shows one of the active type of gyros preliminary to its installation on the ship. It was tested in the position shown in the Electrical Laboratory at the Navy Yard in New York. During this test it was found that the precession of the gyro would easily lift the heavy plate on which it was bolted. The weight of this plate and load was approximately 67,000 pounds.

Fig. 9 shows the precession engine.

FIG 9.



The precession engine.

Fig. 10 shows a rough stabilizing curve, the ends showing the sea running at the time.

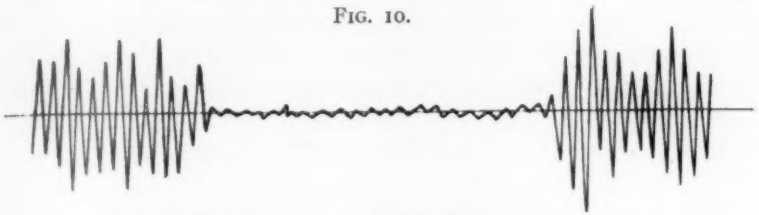
Fig. 11 is a view of the middle portion of the *Worden* from the starboard side, and shows what a comparatively small amount of space is occupied by the stabilizing apparatus.

Fig. 12 shows periodic motion of a ship and the dying-down curve in still water.

Fig. 13, taken from one to two minutes later, shows the dying-down curve when steaming at 15 knots. Both of these

curves were taken in smooth water. Great interest centres in the striking difference between these two curves. This comes from the fact that here, for the first time in the history of navigation,

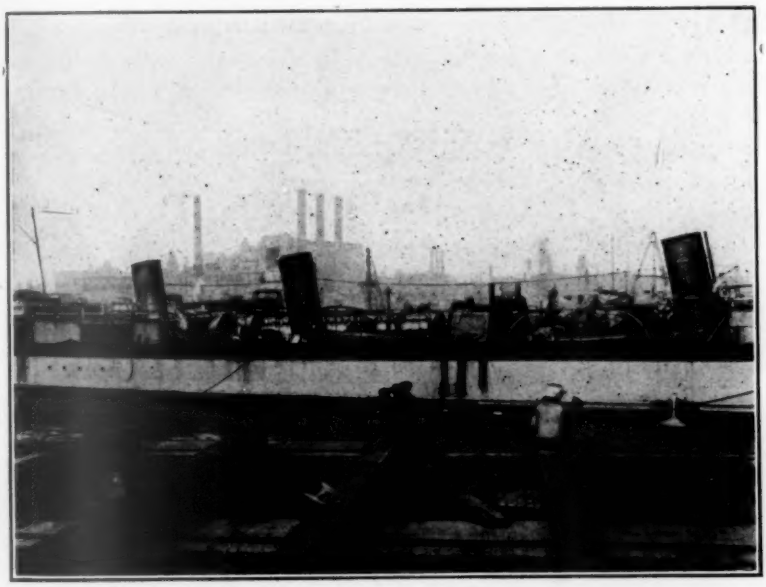
FIG. 10.



A rough stabilizing curve, the ends showing the sea running at the time.

and by the use of the active type of gyroscope, opportunity has been afforded for rolling a ship at will under practically all possible conditions of sea and headway; and here is presented a

FIG. 11.

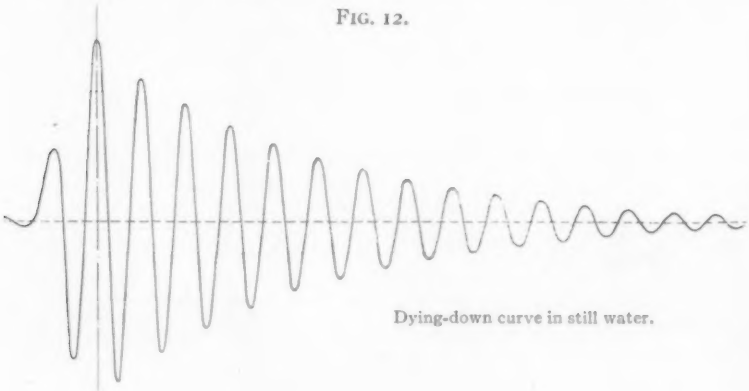


U. S. S. *Worden*, starboard side, middle section of ship only, showing gyro installation.

striking instance of the unexpectedly great effect upon the form-line resistance of the ship due to the relatively stiffer water which is present when steaming as compared with that when

lying to, other conditions remaining the same. The interpretation of these results shows the relatively large amount of power expended due to form-line impingement resistance when steaming. Thus, from these curves may be calculated the exact amount of retardation or slowing-down effect which would be encountered by the ship when rolling as compared with the same ship when not rolling, while steaming at practically any rate.

FIG. 12.



Dying-down curve in still water.

FIG. 13.

Dying-down curve when steaming at 15 knots.

The results of these investigations indicate that quite a large amount of power is expended in driving a vessel at a given speed that rolls over and above one that does not roll.

Through the important work to which only brief reference has here been possible knowledge of the performance of the stabilizing gyro under service conditions has been accumulated.

This is now such as to enable us to calculate with all necessary accuracy the weight and space occupied in connection with practically any plant either for stabilizing or breaking ice; also to predict with certainty what the result will be, the amount of power required, and also to prescribe with fair degree of accuracy about what will be the stabilizing or rolling factor upon any given ship with the new active gyros fitted.

So far as appearance and construction are concerned, it is a far cry from the gyro stabilizer to the gyro compass, although both are founded on the same fundamental phenomenon,—that is, rotation, inertia, and precession.

As necessity is the mother of invention, so the reverse would also seem true, each development in science and engineering necessitating the development of some device or devices to increase the efficiency of the prime development. The magnetic compass served its purpose when ships were made of wood, and the compass could be depended upon to indicate the position of the North approximately. The development of the steel ship, especially the steel man-of-war, has made necessary some compass free from magnetic influences, and the gyro-compass is the result of this necessity.

The use of the magnetic compass involves the application of two classes of errors: variation, or errors arising from forces extraneous to the ship; and deviation, or errors arising from forces within the ship. Both of these classes of errors constantly vary in a manner not capable of prediction.

As the directive force of the magnetic needle is very weak, the compass tends to follow the ship's head instead of holding the meridian; the result is inaccuracy in steaming and observation of bearing.

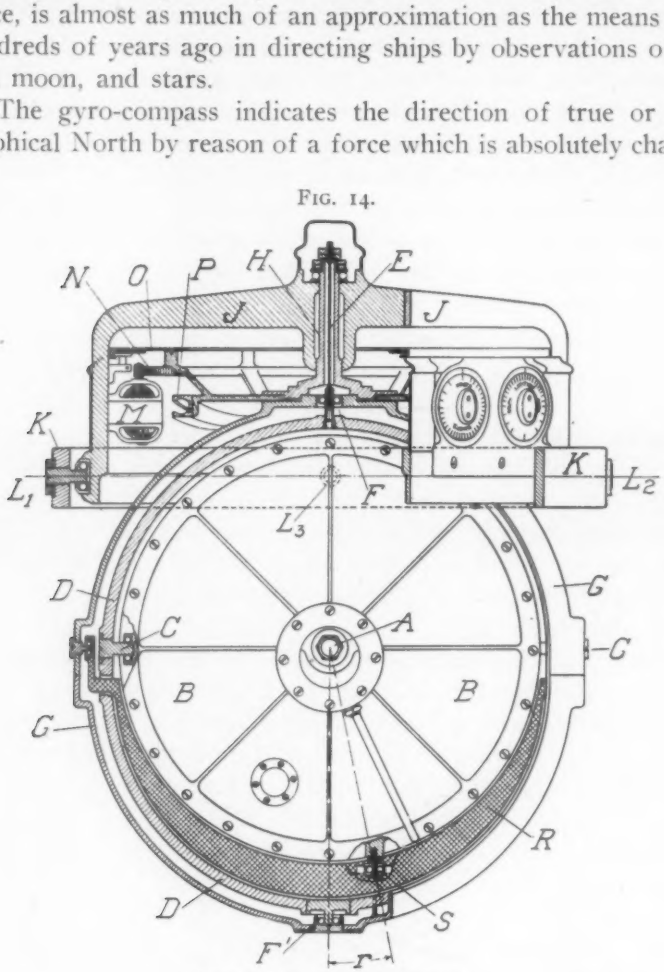
All instruments used for men-of-war must be designed to contribute their part to the efficiency of the ship in battle. The compass in that case must be used behind armor, in which position the magnetic compass is of little or no value. In manœuvring in fleet and in navigating near the coast the use of the magnetic compass in getting bearings of the flagship or objects on shore makes it very inconvenient; as it involves the constant application of errors and transference of compass heading to pelorus, or dumb compass, from which observations are taken.

In the present day of the steel ship and submarine the use of

the magnetic compass, dependent as it is on a weak and variable force, is almost as much of an approximation as the means used hundreds of years ago in directing ships by observations of the sun, moon, and stars.

The gyro-compass indicates the direction of true or geographical North by reason of a force which is absolutely change-

FIG. 14.



Cross-section of master compass.

less and undeviating,—that is, the force of the earth's rotation. An understanding of its operation will be facilitated by referring to Fig. 14, which is an elementary cross-section through the East-West plane of the master compass. The wheel rotates on an axis *A* within the casing *B*. This casing *B* is in turn pivoted upon a horizontal axis *C*—*C*, these pivots being fixed in the vertical ring *D*. Ball bearings are used both at *A* and *C*, and

the wheel runs in a vacuum which is maintained in the casing *B*. The vertical ring *D* is suspended by a stranded wire *E*, and is guided about the vertical axis by the bearings *F*—*F*.

The gyro, its casing, and the vertical ring constitute what is known as the sensitive element. Surrounding this sensitive element is the ring *G*, to which are secured the compass card and the stem *H*, and these parts are made to follow all movements of the sensitive element about the vertical axis. This is accomplished by the means of an electric follow-up system actuating a

FIG. 15.

Stator.

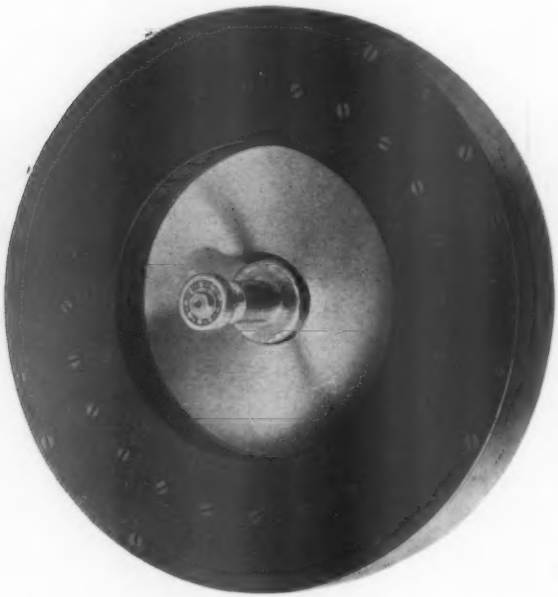
small motor *M*. The gyro, or sensitive element, serves only as the directive part of the instrument, and forms no part in actually driving the compass card or attachments thereof; the actual driving force being provided by the small motor *M*.

It will be clear that the outer ring *G* is at all times rigidly held in position with reference to the supporting frame *J*, although it is at the same time free to move around the vertical axis, and stands in practically constant relation to the gyro wheel or sensitive element. This ring, therefore, serves as a base to which the restraining element, or pendulum *R*, is attached by

means of the pivots shown. This restraining element is attached to the gyro casing at the point *S*.

A rapidly rotating wheel tends to maintain its plane of rotation relative to space, and if the axis of this wheel is not on the North-South meridian the earth in turning on its axis tends to "rotate from under" the gyro wheel and the axis of this wheel inclines with relation to the horizontal. This inclination takes place against the weight of the restraining pendulum *R*, which impresses a force about both the horizontal and vertical axes.

FIG. 16



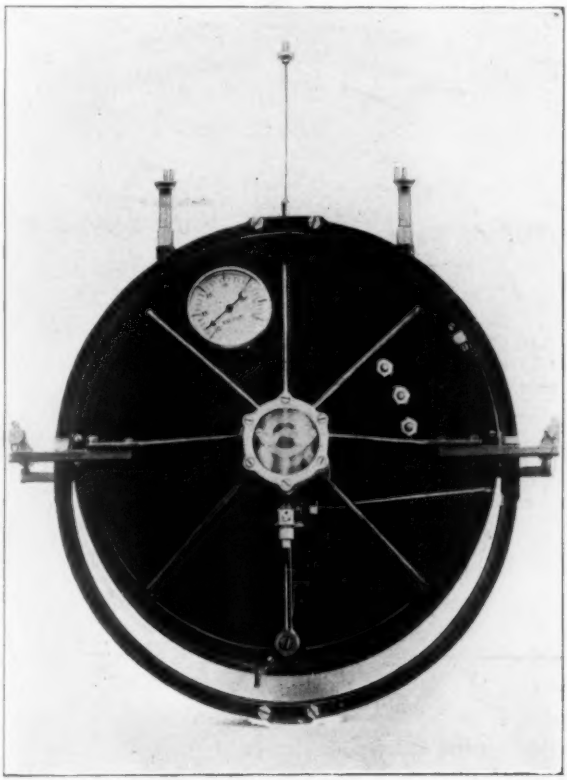
Rotor.

The force about the horizontal axis institutes a precession toward the meridian, while the force about the vertical axis damps this precession to bring the axis of the gyro to rest in a horizontal position when on the meridian, in which case the plane of rotation of the wheel is coincident with that of the earth, and the earth, therefore, no longer tends to rotate out from under the gyro wheel.

The directive force, while very large compared to that of the

magnetic needle, is, nevertheless, small, and the gyro-compass must be made with perfect freedom about the vertical axis. Since the top of the suspension wire is constantly moving to follow the bottom, the gyro is suspended from what is in effect a torsionless wire and perfect freedom is obtained about the vertical axis. This method of suspension has made possible an

FIG. 17.



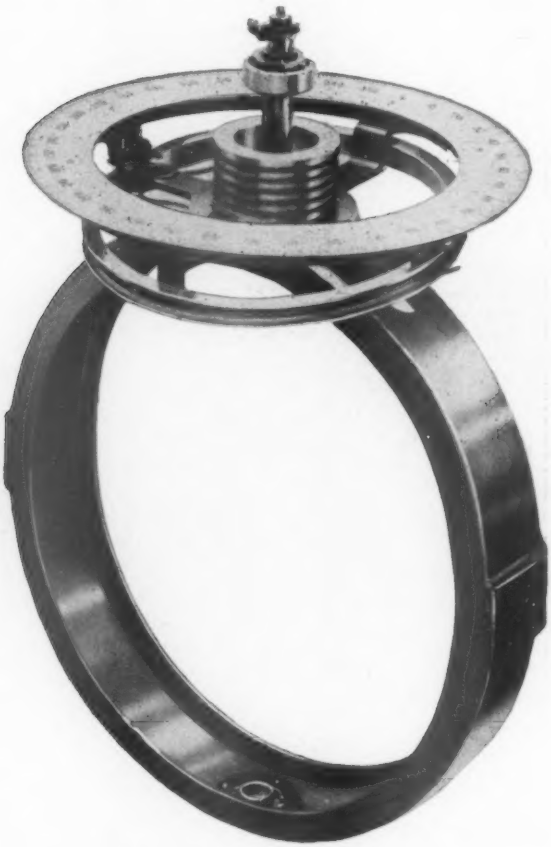
Wheel casing and vertical supporting ring.

extremely accurate instrument which is at the same time very durable and substantial.

To be rigidly exact, I must confess that the gyro does not take up its position exactly in the North and South meridian, but deviates from it by a known amount, the magnitude of which depends upon three variable factors,—namely, the latitude, speed,

and course of the ship on which it is mounted. The northerly and southerly components of speed act to change the apparent direction of the earth's rotation, and the effect of this speed varies with the latitude, inasmuch as the linear speed of any

FIG. 18.



Phantom card, azimuth gear, and cam for automatic correction mechanism

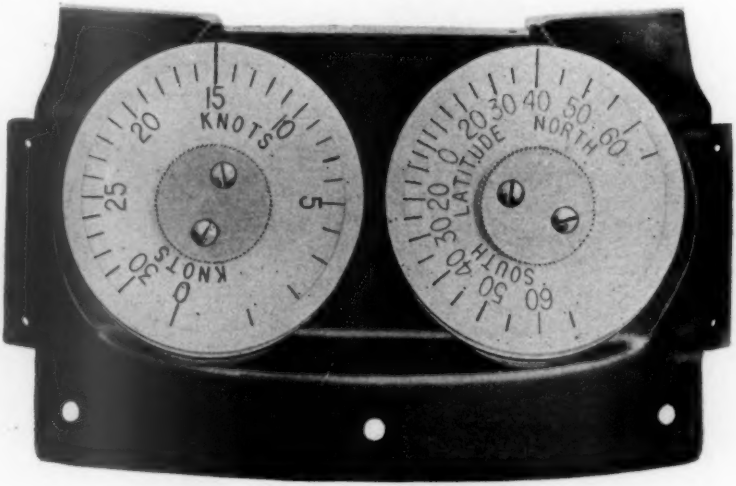
point on the earth's surface varies with the latitude. Another latitude correction is introduced by the fact that the compass lags behind the meridian by an amount varying with the latitude; this lag being due to the fact that a certain amount of force is impressed about the vertical axis by the restraining pendulum for

preventing oscillations. The total correction is expressed by the equation:

$D = (H \cos K \div \cos L) \pm \text{Tan } L$. Where H = speed; K = course, and L = latitude.

An automatic correction device is attached to the compass card which, when set for approximate speed and latitude, applies all of these corrections. This device consists of a number of cams so laid out that when the dials are set for ships' approxi-

FIG. 19.



Automatic correction dials, setting 15 knots, 40° North latitude.

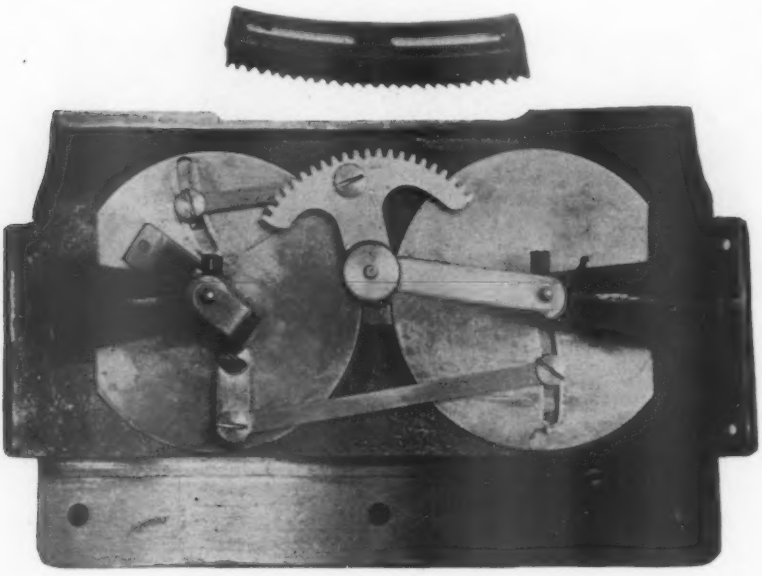
mate speed and latitude the various factors are combined and the correction is automatically applied.

The gyro-compass can, of course, be placed well below the water line and behind the heaviest armor of the ship. Its indications are repeated to any desired station on the ship by means of an auxiliary system operating the cards of so-called "repeater compasses." This system consists of a transmitter on the master compass which controls the poles of a small motor in the repeater compass in such manner that the armature of this motor is turned by steps to follow the moving dial of the master compass. The armature of this small motor is geared to the repeater dial so that one revolution produces a 2 degree movement of the

dial. The motor has six poles controlled in pairs, so that the armature stands between one pair, then half-way between that pair and the next, then between the next pair, and so on, having twelve resting positions in each revolution. The repeater dial, therefore, moves $\frac{1}{6}$ degree for every $\frac{1}{6}$ degree movement of the master compass dial, yielding a maximum error of $\frac{1}{12}$ degree.

The results accomplished by the gyro-compass in service have been of the greatest interest in bringing out many unex-

FIG. 20.



Back of correction device.

pected advantages. It provides an accurate means of navigating, and a means which is perfectly free from lag. This results in considerable saving in coal by increasing the accuracy with which the courses are run from point to point and by decreasing the amount of helm used, inasmuch as the helmsman has a compass without a lag and can keep the ship on the course by using a small amount of helm. Many of the navigators who have used the compass estimate that the saving in coal accomplished amounts to eight or ten thousand dollars during a year of ordinary service. Applied to battleships, the results accomplished

are of the greatest importance. The ship may be steered as well from an armored station as from an unarmored station. With the gyro-compass the helmsman can, therefore, be stationed in the steering engine-room, where he is well protected and where there is little chance for failure of connecting him with the steering engine mechanism. The commanding officer can then manœuvre the ship from the conning tower or other armored station

FIG. 21.

Master compass binnacle, lower part down.

by maintaining communication with the helmsman over the voice-tube or telephone. In formation in column, it is found that the position of ships can be maintained with far greater accuracy, as the small use of helm is conducive to the maintenance of constant speed of all ships. With the use of the magnetic compass the varying amounts of lag result in varying the amounts of helm used and in consequent variations of speed. This variation in speed makes it difficult to maintain the distance

between ships. In formation on line, or line of bearing, no possibilities exist for errors due to misapplication of the compass deviation or correction in closing or opening intervals by changing course toward or away from the flagship. The necessity for continuously applying deviation and setting the pelorus, or dumb compass, is avoided. A special type of bridge or conning tower

FIG. 22.

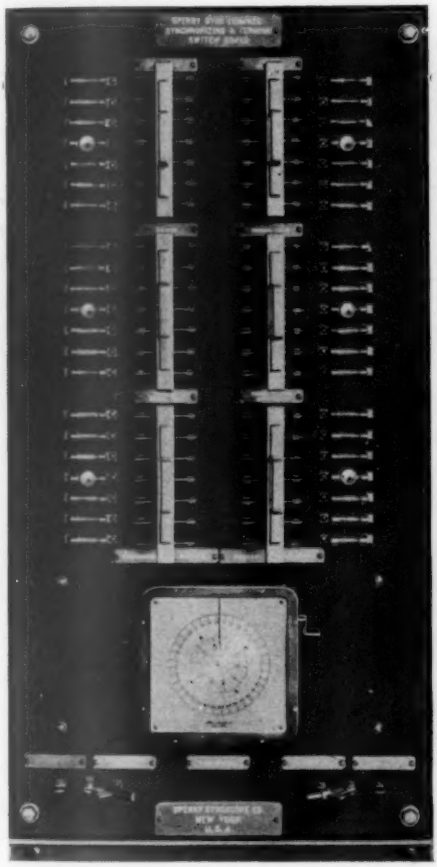
Master compass card from helmsman's position.

repeater, designed to replace the old pelorus or dumb compass, makes it possible to get the true bearing of the flagship directly. This is of great advantage, also, in navigating near the coast, as true bearings of objects on shore may be obtained with great accuracy. The use of the gyro-compass on submarines is estimated to have increased their efficiency fully 50 per cent. by providing a means for steering an accurate course when submerged.

Fig. 15 is a photograph of the stator of the induction motor driving the gyro wheel. This stator is mounted on the inner side of the gyro casing shown in Fig. 14.

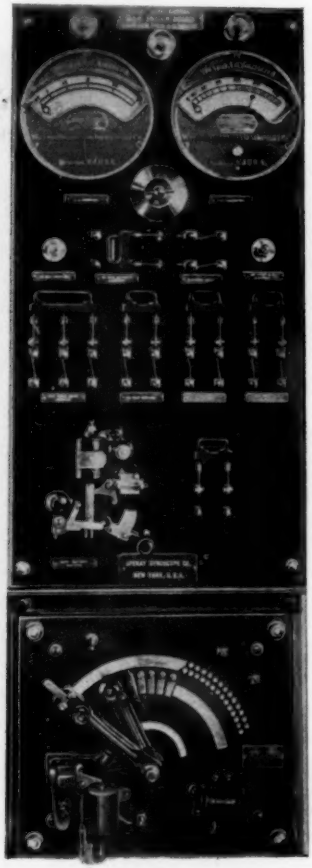
Fig. 16 is a photograph of the rotor, having inlaid on its inner periphery the short-circuited bars of the induction motor.

FIG. 23.



Synchronizing panel.

FIG. 24.



Main switchboard.

Fig. 17 is a photograph of the gyro mounted in the vertical cardan ring.

Fig. 18 is a photograph of the "phantom" ring which surrounds the sensitive element and is driven to follow it.

Fig. 19 is a photograph of the front view of the correction device.

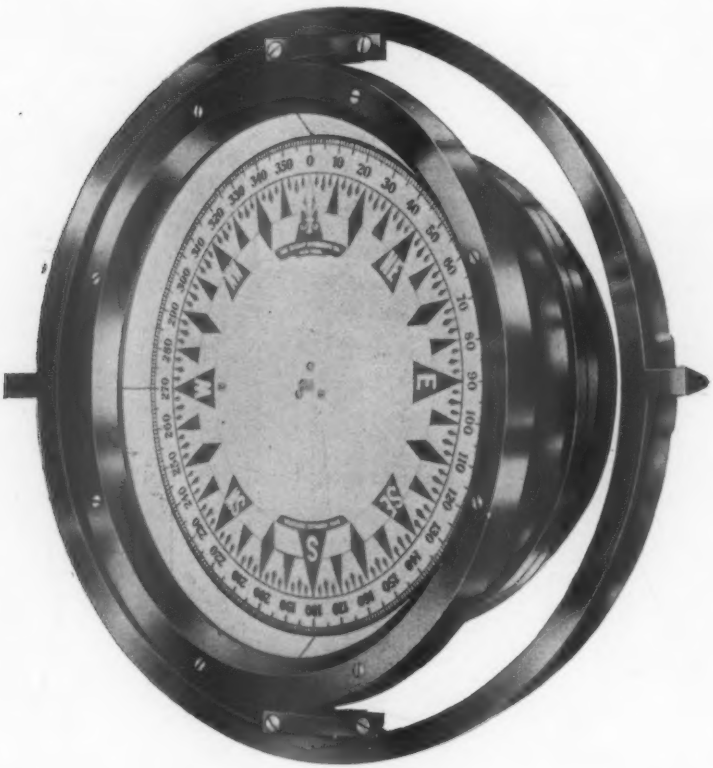
Fig. 20 is a back view of the correction device.

Fig. 21 is a view of the assembled gyro-compass.

Fig. 22 is a top view of the compass.

Figs. 23 and 24 are views of the switchboards.

FIG. 25.



Repeating compass, binnacle type.

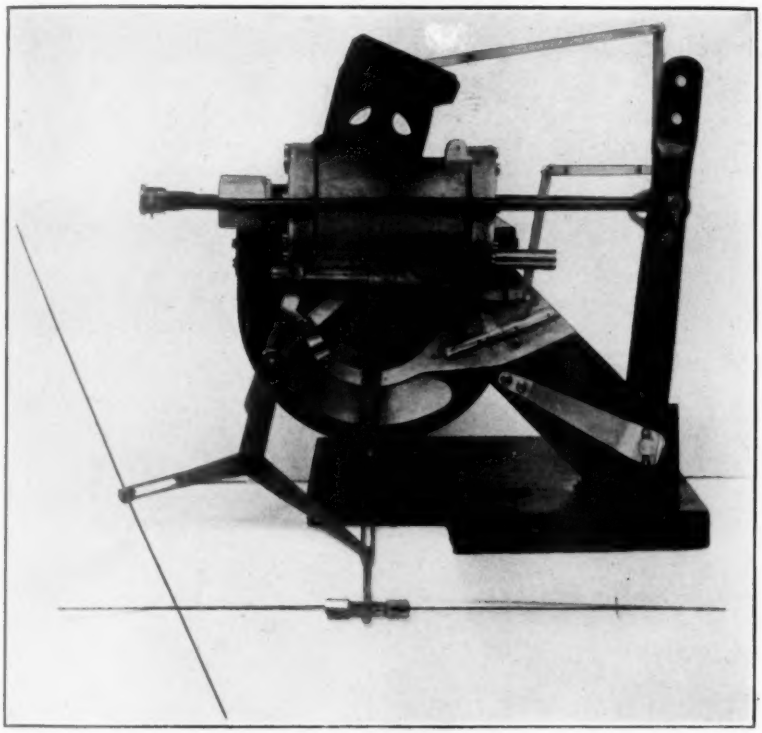
Fig. 25 is a view of the repeater, or auxiliary compass.

Perhaps the most interesting of all the apparatus which we have developed is the aëroplane stabilizer. Air is a very unstable medium, and the development of the heavier-than-air machine has shown us that the atmosphere is in a constant state of turmoil, rendering its navigation perilous. The aviator must

work constantly to maintain the stability of the machine about all three axes. With the present machines very long flights are nearly beyond the endurance of the aviator, and even short flights are difficult when the weather is at all bad.

Each aëroplane stabilizing equipment comprises a combination of devices for maintaining longitudinal stability and a com-

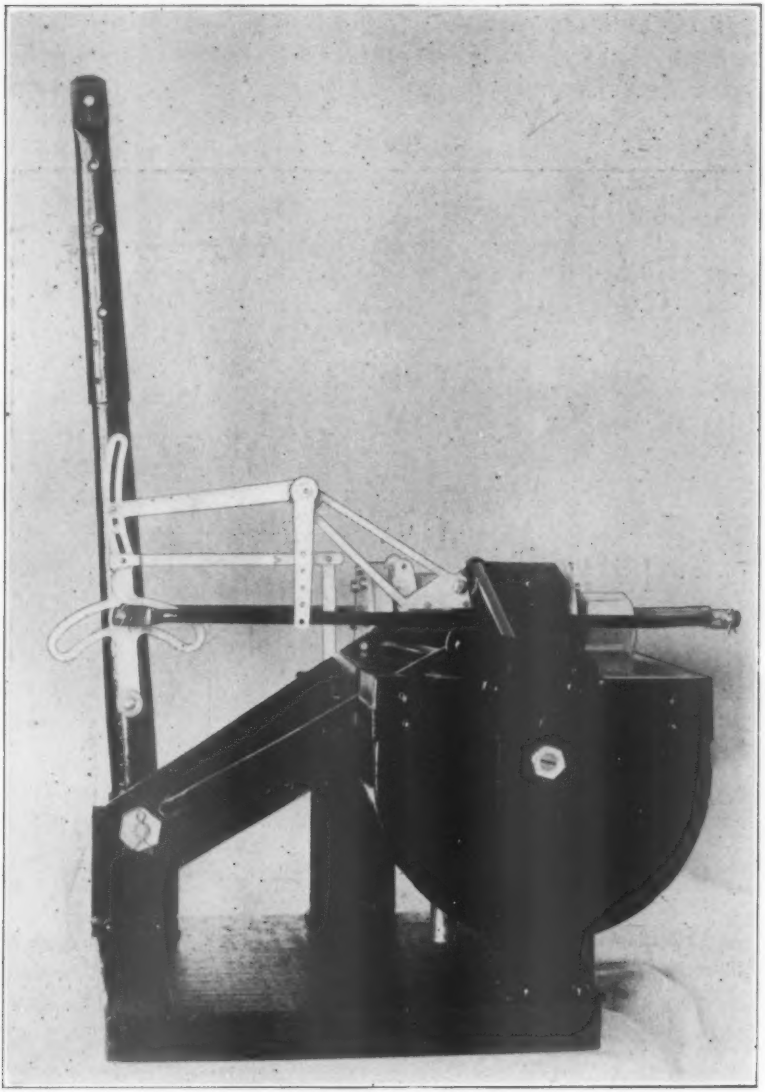
FIG. 26.



The lateral stabilizer.

bination for maintaining lateral stability. The longitudinal stabilizer uses three directive factors for controlling the movements of a pilot valve, which in turn controls a compressed-air cylinder operating a piston attached to the horizontal rudders. The controlling factors are: first, the gyro which through the pilot valve operates the horizontal rudders against tendency to tip about the horizontal axis; second, an air platen which operates

FIG. 27.



The longitudinal stabilizer.

the pilot valve to volplane the machine in case the speed drops below the critical speed necessary for sustaining the plane; third, a hand-setting device which permits the aviator to set the stabilizer for any inclination of climb or descent. The air platen further acts to adjust the throw of the levers so that when running at slow speeds a small tipping is counteracted by a suitable throw of the rudders. This is made necessary by the fact that the plane is, of course, more sensitive to inclinations of the rudders when running at high speed.

The lateral stabilizer serves as a directive factor, acting on the pilot valve to control the movements of the ailerons so that they operate to counteract against tipping laterally. When turning, the lateral stabilizer operates the control mechanism to bank the machine to an angle sufficient to prevent skidding.

The gyros of the aëroplane stabilizer are continuously spun by three-phase alternating current derived from a small generator driven from the shaft of the engine. This generator is designed to develop alternating current for driving the gyros, low-voltage direct current for exciting its own fields, and single-phase alternating current for use in connection with the radio set. The low-voltage direct current may also be used for ignition service of the engine.

It is an interesting fact that the gyros connected to the generator circuit act as boosters to restore part of the energy given to them when a circuit to the wireless is closed; thus momentarily the wireless equipment is supplied not only by the generator but also the gyros acting as induction generators.

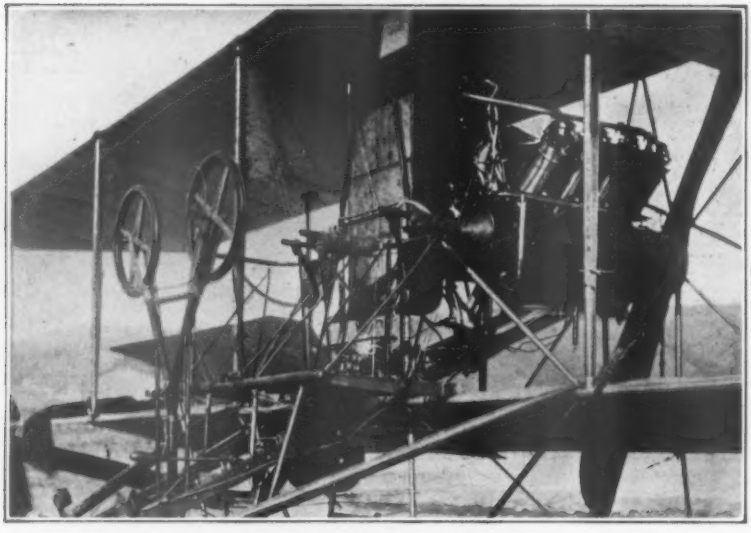
A valve connected to the compression space of one of the engine cylinders automatically stores compressed gas in a small accumulator tank, from which it is used to operate the pistons controlling the ailerons and rudders.

The same type of stabilizer may be used on any type of aëroplane, as the installation simply involves supporting it firmly on the machine and attaching the arm operated by the compressed-air piston to the wires or levers of the existing hand control. Both ends of the compressed-air pistons are provided with valves, all of which may be opened by releasing a thumb button attached to the steering wheel of the aëroplane. When these valves are opened the stabilizer continues to function, so far as the relation of all of its parts is concerned, but has no effect on

the ailerons or rudders, as the piston is prevented from doing any work. This makes it possible for the aviator to instantly shift from hand control to automatic control.

The weights and dimensions of the various parts of the stabilizer are surprisingly small. The weight of the generator is about 25 pounds and it occupies a space of about six by six by ten inches. The lateral stabilizer weighs about 18 pounds and is small enough to be conveniently disposed at the back of the

FIG. 28.



Aëroplane showing both stabilizers installed.

aviator's seat. The longitudinal stabilizer weighs about 17 pounds and is placed below the aviator's seat in such a position that he can see its operation at all times.

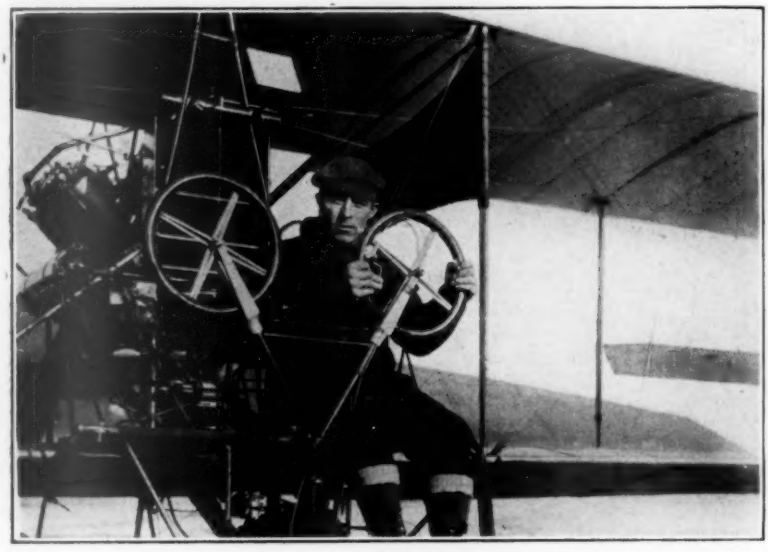
The automatic control of stability of the heavier-than-air machines will do much to decrease the growing list of fatalities, as it provides a means for acting simultaneously with the disturbing air currents, whereas the aviator must always wait until the effect has manifested itself before he applies the remedy, and then he very often misjudges the amount by which he should move his controls.

The automatic control of stability will be especially valuable to the military use of the aëroplane, as it will make it possible to fly in almost any condition of weather and will make long flights possible. In reconnaissance service only one man will be necessary, as the machine may be controlled automatically while the aviator makes sketches, records information obtained, or operates the radio set to communicate with his base.

Fig. 26 is a view of the lateral stabilizer.

Fig. 27 is a view of the longitudinal stabilizer.

FIG. 29.



Illustrating thumb button for cutting out automatic control.

Fig. 28 shows both stabilizers installed on the Curtiss hydro-aëroplane.

Fig. 29 shows the thumb button by means of which the stabilizers may be cut in or out.

In conjunction with the U. S. S. *Worden* trials were used interesting apparatus for recording the roll and pitch of the ship. Pendulous gyros were used to maintain the athwartship and fore and aft axes, and these gyros operated pencil arms resting on a paper tape moved by clockwork. It was found that this mechanism was so sensitive to changes in the angle of roll and pitch

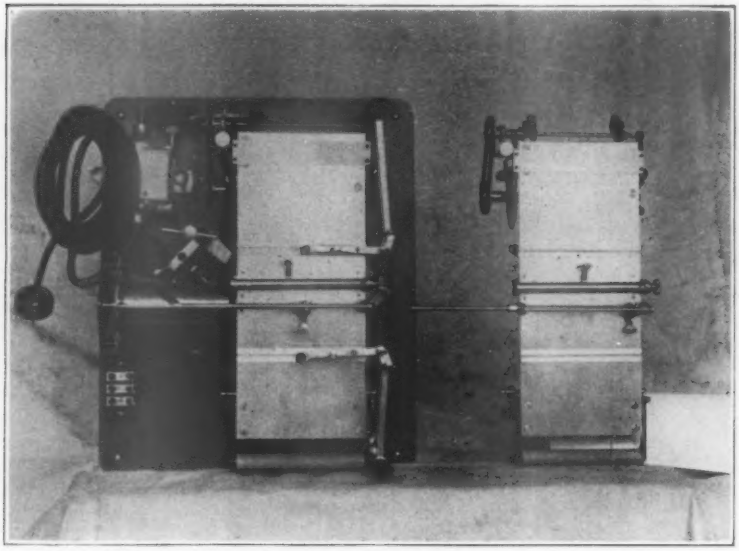
of the vessel that it would indicate the roll caused by two men moving from one side of the ship to the other.

Fig. 30 is a top view of the roll and pitch recorder.

Fig. 31 is a side view of this instrument.

The artificial horizon is the most recent application of the gyroscope. Although the problem at first appeared somewhat complicated, later developments showed that a 12-inch circular mirror could be maintained in a horizontal position with perfect accuracy and by the use of a very simple combination of gyros.

FIG. 30.

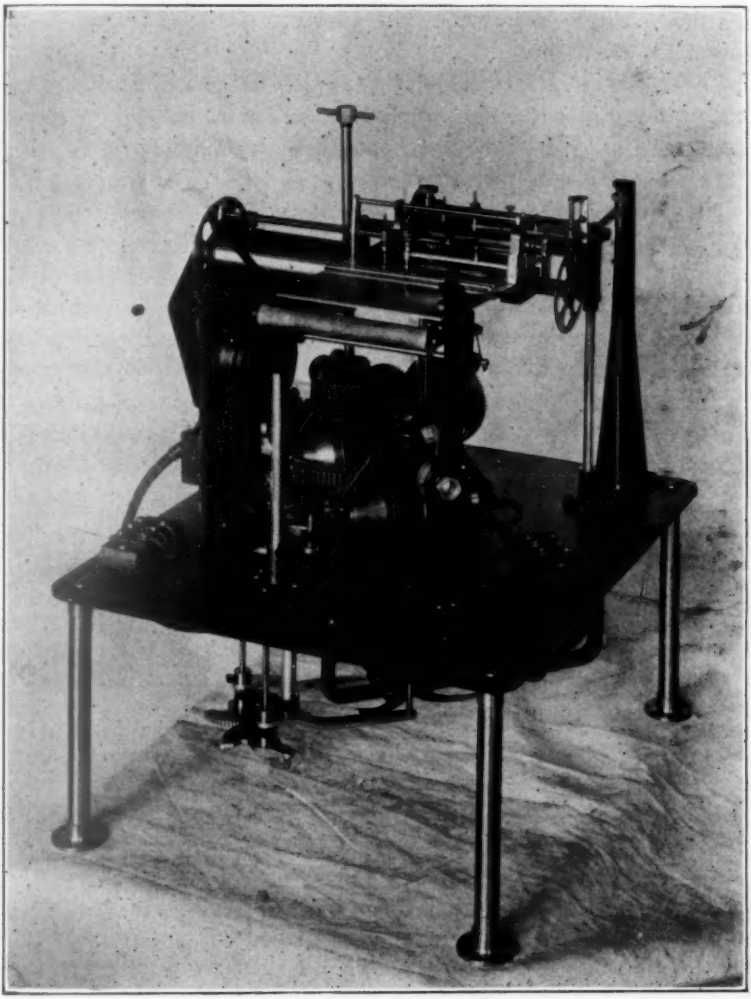


Top view of roll and pitch recorder and duplicate platten.

The artificial horizon as now constructed is portable and entirely self-contained. The mirror is levelled by hand. The double altitude of the sun or heavenly body is observed by measuring the angle between the body and its reflection; the mirror is then readjusted and the observation is repeated. If any error was introduced in the first observation by inclination of the mirror, this error will be equal and opposite in the second observation, and an average of the two observations, divided by 4, gives the exact altitude of the body. Errors are frequently introduced in navigation when measuring the altitude of a heavenly body

above a false horizon, caused by mist or by the mirage effect of the heat of the air on tropical seas. Very frequently observa-

FIG. 31.



Side view of roll and pitch recorder.

tions of the sun or heavenly bodies could be taken were it not that the horizon is obscured by low-lying banks of fog or darkness. The artificial horizon provides a means for eliminating

these errors in observations of altitude, and makes it possible to accurately measure the altitude of any heavenly body that can be seen, whether or not the horizon is obscured. The first artificial horizon has just been completed and is now undergoing a test under the supervision of the authorities of the United States Naval Observatory.

Though they differ widely in the details of their construction and in the results to be accomplished, all applications of the gyroscope are founded on the phenomenon of inertia relative to space. This broadly useful principle gives us the means for maintaining a base line or fixed axis from which we operate to quench roll in the case of the stabilizing gyros; to hold the North and South meridian, as in the case of the gyro-compass; to control the ailerons and rudders of the aëroplanes; to record the movements of vessels in rolling and pitching, and to hold the mirror of the artificial horizon horizontal.

The knowledge obtained in the engineering applications of the gyroscope has opened a wonderful vista of possibilities for accomplishing results of the greatest usefulness to mankind.

Magnesite Deposits in Mexico. (*Board of Trade J.*, Jan. 9, 1913.)—The Consul at La Paz, Mexico, states that large deposits of high-grade magnesite, containing 92 per cent. of magnesium carbonate, are found near Magdalena. The largest bed is about 30 acres in area, and is situated on the Margarita Islands; deposits have also been found on Cedros Island. The mineral is so hard as to require blasting for removal. A company has been formed to develop these deposits. One calcining plant will be installed on Cedros Island and another on Margarita Island, each with a capacity of 200 tons per day.

New Leadless Storage Battery. ANON. (*Sci. Amer.*, cvii. 25, 527.)—A Swedish inventor has put on the market a new type of alkaline storage cell. The plates consist of inactive retainers which are loaded with active material, nickel oxyhydrate mixed with graphite in the positives, and a finely-divided alloy of iron and cadmium and certain other substances in the negatives. This new cell resembles the Edison cell, not only in the electro-chemical reaction, but also in the fact that extreme ingenuity is shown in the mechanical construction to obtain high efficiency in space and weight and durability.

THE CHEMISTRY OF THE SOIL NITROGEN.[1]

BY

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(CONTRIBUTION FROM THE CHEMICAL RESEARCH LABORATORY, SOILS SECTION, IOWA AGRICULTURAL EXPERIMENT STATION.)

THE question of plant food is one of the most important physiological problems confronting the plant physiologist, botanist, horticulturist, agronomist, forester, and, generally speaking, all those who have to deal with plants. It is of great moment both from a scientific and practical point of view. Increased knowledge as to how to utilize the plant food, especially the one which is already contained in the soil, seems to be the key for raising bigger crops and at less cost. It is with the soil nitrogen that this article is chiefly concerned with.

The nitrogen contained in soils is made up of ammonia, nitrites, nitrates, and of organic compounds. The latter usually form the bulk of the soil nitrogen. In speaking, however, of nitrogen as plant food we, in a more limited sense, usually mean by that the so-called available nitrogen which is necessary for the growth, development, multiplication, and, generally speaking, for all life functions of the plants.

It is true that available nitrogen—ammonia and nitrates—is constantly coming to the soil with all kinds of precipitations, like rain, dew, snow, etc. As is well known, however, the total amount of available nitrogen obtained in this way is only a few pounds per acre.[2] The nitrogen in the form of commercial fertilizers is quite expensive, costing about 18 cents per pound.

[1] Communicated by the author.

[2] According to experiments conducted in Prussia, the total amount of nitrogen coming into the soil with atmospheric precipitations is from 11.6 to 18.2 kilogrammes per hectare (10.3 to 16.2 pounds per acre and year). See "Die Chemie in ihrer Anwendung auf Agricultur und Physiologie," J. v. Liebig, p. 44 (1876).

According to later experiments, the amount of atmospheric nitrogen which reaches the soil is still smaller.

True, the processes of Eyde and Haber will make it cheaper. Yet the cheapest and best source of nitrogen is the soil itself, which contains the remains of animals and plants, in all of which nitrogen is present, chiefly in the form of organic compounds. The latter, however, have not fully and advantageously been utilized because of our lack of knowledge concerning their chemical nature. In the light of the latest researches into the character of soil organic matter, and especially of soil organic nitrogen, the knowledge of the chemical nature of the organic nitrogenous compounds present in soils represents the very means for the solution of the problem as to how fully to utilize the soil nitrogen. In this connection it is well to bear in mind that available nitrogen, in a wider sense, consists not merely of ammonia and nitrates present as such in soils, but also of those organic nitrogenous compounds which readily undergo the processes of ammonification and nitrification.

As to the amount of ammonia present as such in Michigan peat soils, it was shown [3] to be quite small,—namely, from about one-tenth to one and one-half per cent. of the total nitrogen contained in the peat. This was also shown to be true of Iowa [4] soils in which the total quantity of ammoniacal and nitric nitrogen ranged from one to somewhat more than 2 per cent., calculated to the total soil nitrogen. The extension of our investigations has demonstrated that the above facts hold also good for Iowa soils which were fertilized with various organic materials and grew a considerable variety of crops.[5] In all of the above soils from 98 to 99 per cent. of the total soil nitrogen consisted of organic nitrogenous compounds. The extraction of these compounds by boiling the soils with sulphuric or hydrochloric acid led to results showing that those organic compounds [6] were made up chiefly of acid amides, diamino acids, and monoamino acids. Since, however, acids are known to hydrolyze

[3] Jodidi, S. L., *Journ. Amer. Chem. Soc.*, 32, 396 (1910); also *Michigan Agr. College Exp. Sta. Techn. Bul.*, No. 4 (1909).

[4] Jodidi, S. L., *Journ. Amer. Chem. Soc.*, 33, 1226 (1911); also *Iowa State College Agr. Exp. Sta. Research Bul.*, No. 1 (1911).

[5] Jodidi, S. L., *Journ. Amer. Chem. Soc.*, 34, 94 (1912); also *Iowa State College Agr. Exp. Sta. Research Bul.*, No. 3 (1911).

[6] *Loc. cit.*

proteins which are always present in soils, the question naturally arises: Are those acid amides and amino acids—found in the acid extracts of the soils—as such contained in the soils, or are they merely decomposition products of the hydrolyzed proteins?

Just how much of the soil organic nitrogen is made up of proteins, and how much of acid amides, amino acids, or other nitrogenous compounds, and what the chemical nature of the latter is, cannot at present fully be answered. The investigations which systematically deal with the chemical nature of soil organic nitrogen date back only a few years and are still far from being completed. However, with the knowledge already at our command we are able to answer the above question in part.

The consideration of the fact that tissues of plants and animals, on their death, are constantly coming into the soil, is proof that the latter must contain a part of its nitrogen in the form of proteins. The work of S. Suzuki,[7] namely, "Studies on Humus Formation," led him to the conclusion that humic acid—obtained by extraction with a 2 per cent. sodium hydroxide solution—is made up of proteins which are combined more or less intimately with the black substances. As early as 1873 W. Wolf[8] made the assumption that the organic nitrogenous compounds present in soils are of the acid amide type. In their investigations in connection with amides Berthelot[9] and André found that hydrolyzing means, such as alkalies, acids, or even water, split off a portion of the nitrogen contained in humus in the form of ammonia. This, they concluded, must be due to the presence of amides in the soil. Based upon the fact that he found considerable amounts of ammonia in soils which were previously treated with acids or alkalies, but that ammonia as such was contained in the same soils in but minimum quantities, A. Baumann[10] suggested the possible presence of amino compounds in soils. The experiments of A. Hébert[11] have shown that when soil is heated with water to temperatures above 100° C. the organic nitrogenous substances present in the soil split off their

[7] *Bul. College Agr.*, Tokyo, 7, 513–529 (1907).
[8] *Landw. Jahrbücher*, 2, 389 (1873).
[9] *Compt. rend.*, 103, 1101 (1886).
[10] *Landw. Vers.-Stat.*, 33, 247 (1887).
[11] *Annales agronomiques*, 15, 355 (1889).

nitrogen in the form of ammonia. The results of his experiments go to show that the ammonia thus obtained is due to the occurrence in the soil of amido compounds. While the presence of amino nitrogen in soils was qualitatively demonstrated by Warington[12] and Sestini,[13] Dojarenko[14] estimated quantitatively the amounts of amido and amino nitrogen present in humic acid which he extracted from Russian black soils. The isolation of a definite organic compound from an Hawaiian soil was accomplished by Shorey[15] in 1906, who identified it as picoline carboxylic acid.

The writer[16] was the first to show the presence of diamino acids in soils. While their presence was first demonstrated by him through the application of the Hausmann[17] method as modified by Osborne[18] and Harris, it was later verified and confirmed by the writer,[19] as well as by other investigators,[20] in a variety of ways.

Inasmuch as the amino acids and acid amides make up a considerable part of the acid extract of soils, it may be worth while to consider here those compounds somewhat at length.

Theoretically, the primary disintegration products of proteins—acid amides, mono-amino acids, diamino acids—as well as lecithin derivatives, etc., may undergo chemical changes in the soil in a variety of ways. In case it is a simple hydrolytic process we would have the following equations:

$$\underset{\text{Acid amide.}}{R\cdot CO\cdot NH_2} + H_2O = \underset{\text{Fatty acid.}}{R\cdot CO\cdot OH} + NH_3$$

$$\underset{\text{Mono-amino acid.}}{R\cdot CH\cdot NH_2\cdot COOH} + H_2O = \underset{\text{Hydroxy acid.}}{R\cdot CH\cdot OH\cdot COOH} + NH_3$$

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[12] *Chem. News*, 55, 27 (1887).

[13] *Landw. Vers.-Stat.*, 51, 153 (1899). *Abs. in Expt. Sta. Rec.*, 10, 424 (1898).

[14] *Landw. Vers.-Stat.*, 56, 311 (1902).

[15] Annual Report of the Hawaii Agr. Exp. Sta., 1906, p. 52.

[16] *Journ. Amer. Chem. Soc.*, 32, 396 (1910); *Michigan Agr. Exp. Sta. Tech. Bul.*, No. 4.

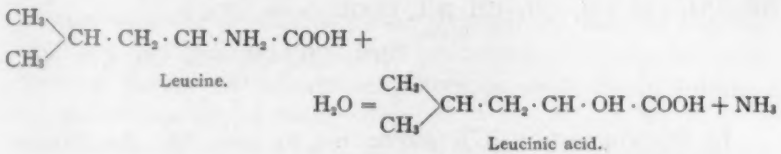
[17] *Zeit. physiol. Chem.*, 27, 95 (1899); 29, 136 (1900).

[18] *Journ. Amer. Chem. Soc.*, 25, 323 (1903).

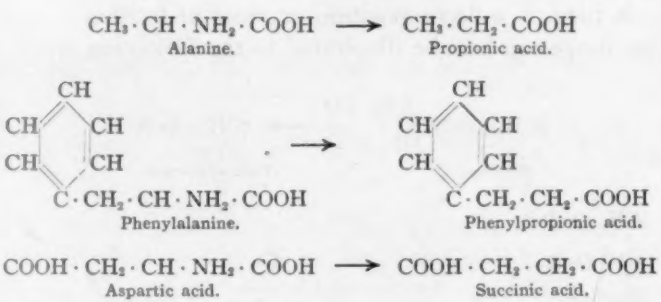
[19] *Loc. cit.*

[20] *Journ. Biol. Chem.*, vol. viii, No. 5, p. 381 (1910).

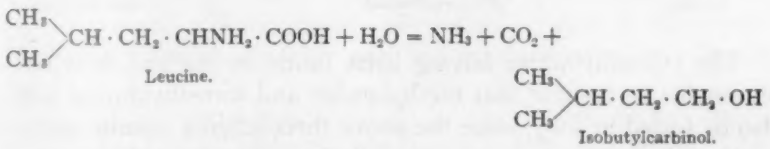
In the latter case the leucine, for instance, would yield leucinic acid according to the equation:



Deamination of mono-amino acids can take place in such a way as to produce fatty acids according to the following schemes:



Through fermentation the amino acids can yield alcohols. Leucine, *e.g.*, can give isobutylcarbinol (amylalcohol) according to the following equation:



Again, the diamino acids may split off CO_2 under the formation of amines. Lysine,[21] for instance, is known to split off

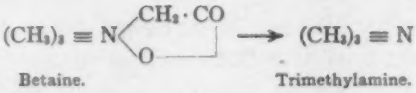
[21] *Zeit. physiol. Chem.*, 29, 334 (1900).

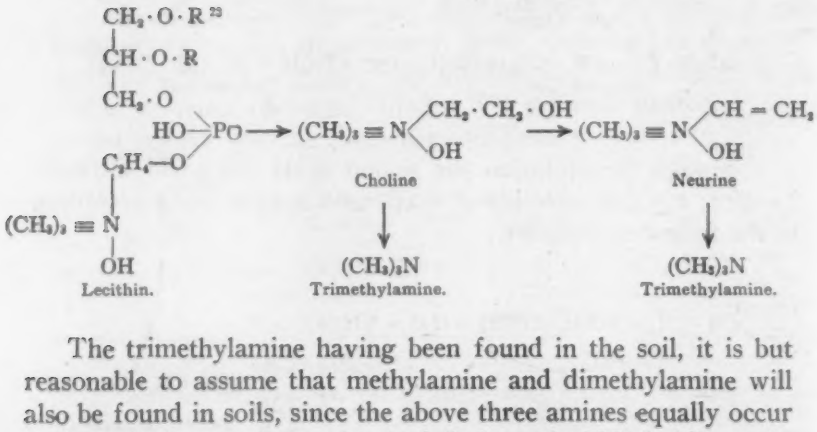
CO_2, under the action of micro-organisms, whereby cadaverine (pentamethylene diamine) results:

$$\underset{\text{Lysine.}}{NH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH \cdot NH_2 \cdot COOH} \longrightarrow CO_2 + \underset{\text{Cadaverine.}}{NH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot NH_2}$$

In this connection it is interesting to note that the amines choline [22] and trimethylamine were extracted from the soil. There can be little doubt, if any, that trimethylamine was formed in the soil secondarily from betaine, choline, and neurine, of which betaine is as such widely distributed in the vegetable kingdom, and the neurine is closely related to choline, which latter, in turn, is a decomposition product of lecithin.

The above can best be illustrated in the following way:





The trimethylamine having been found in the soil, it is but reasonable to assume that methylamine and dimethylamine will also be found in soils, since the above three amines equally occur as degradation products of rotted flesh, of lecithin-holding substances, etc.

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[22] Shorey, E. C., original communications, VIII Intern. Congress of Appl. Chem., vol. xv, p. 249.

[23] R stands for the radical of the fatty acids, like palmitic, stearic, oleic, etc.

Just as cadaverine can result secondarily from lysine—a primary cleavage product of proteins—putrescine can result secondarily from ornithine, which can be formed, *e.g.*, from the protein cleavage product arginine through the enzyme arginase, or from ornithuric acid through hydrolysis. Hence, the occurrence in the soil of cadaverine, putrescine, and related amines is altogether not out of the question.

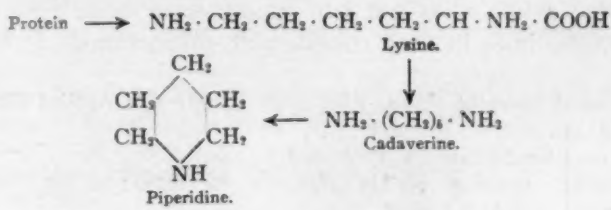
The above can best be illustrated by the following equations:

$$\underset{\text{Lysine.}}{NH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH \cdot NH_2 \cdot COOH} = CO_2 + \underset{\text{Cadaverine.}}{NH_2 \cdot (CH_2)_5 \cdot NH_2}$$

$$\underset{\text{Ornithine.}}{NH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH \cdot NH_2 \cdot COOH} = CO_2 + \underset{\text{Putrescine.}}{NH_2 \cdot (CH_2)_4 \cdot NH_2 \cdot}$$

$$\underset{\text{Arginine.}}{HN = C(NH_2) \cdot NH \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH(NH_2) \cdot COOH} + H_2O = OC(NH_2)_2 + \underset{\text{Ornithine.}}{NH_2 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH \cdot NH_2 \cdot COOH}$$

The occurrence in the soil of picoline carboxylic acid, as well as of other pyridine derivatives, may very well be due to the existence in the soil of vegetable residues containing a pyridine nucleus, bearing in mind that many plants produce alkaloids all of which are closely related to pyridine, their parent body. However, pyridine and its derivatives may also be formed from proteins. Lysine, for instance, which is a primary cleavage product of proteins, is known, under the action of micro-organisms, to yield pentamethylene diamine. The hydrochloride of the latter yields, on distillation, piperidine, which is hexahydropyridine. The above facts may find expression in the following way:



There can hardly be any doubt but that the primary formation of lysine from proteins and the secondary degradation of lysine to cadaverine actually take place in the soil, since lysine[24] could be extracted from soils, and this diamino acid is known under the action of bacteria—so numerous in the soil—to split off carbon dioxide under the formation of pentamethylene diamine. Whether the latter can, under the influence of the agencies active in the soil, be converted into piperidine has not yet been demonstrated.

Proteins, however, can, in the process of decomposition, yield pyridine compounds also in another way. It is fairly well known that some of the primary decomposition products of proteins, like lysine, tyrosine, tryptophane, and glucoseamine, secondarily yield humin substances. The latter, in turn, as was shown by Samuely,[25] yield, on reduction, pyridine.

Intermediary products can be, and actually are being, formed in the soil when conditions in it are favorable for the process of putrefaction. When, however, conditions in the soil are favorable for the process of cremacansis—in case the soil is well drained, porous, well cultivated, and hence contains a good deal of air—the organic substances will naturally, sooner or later, completely be destroyed under the formation of carbon dioxide, water, and ammonia.

Do amino acids, acid amides, purine bases, etc., as such, occur in the soil? This question must be answered in the affirmative. Aside from the fact that some of these compounds may come into the soil with manures, or may be formed in it as the result of degradation of protein bodies, we must not forget that the nitrogen in plants consists in part of amino acids as such. E. Schulze,[26] for instance, has shown that in beets but 21.6–38.9 per cent. and in potatoes only 56.2 per cent. of the total nitrogen consists of protein bodies. Further, it was found by O. Kellner[27] that amino acids and acid amides occur quite generally in plants, sometimes in very considerable proportions. It matters

[24] Original communications, VIII Inter. Congress of Applied Chemistry, vol. xv, p. 249.

[25] *Beitr. Chem. Physiol. u. Path.*, 2, 355 (1902).

[26] *Landw. Versuchsst.*, 18, 320 (1875); 21, 86 (1878); 69, 393 (1908).

[27] *Landw. Yahrb.*, 8 (1879).

little whether those compounds are the result of degradation of proteins through the action of proteolytic enzymes, which is especially the case in germs of plants or in the young sprouts, or whether they represent transition products from the inorganic nitrogen (taken up by the plants) to the synthesis of proteins in the vegetable organism. The fact remains that acid amides and amino acids as such occur in plants, and hence they naturally come, on the death of the plants, into the soil.

The above statement does not stand in contradiction to the fact that water extracts of soils usually contain but small amounts of nitrogenous bodies other than ammonia and nitrates. It should be borne in mind that many organic nitrogenous compounds, especially the amino acids, are able to combine with mineral bases acids or salts in order to form double compounds. The latter show physical properties different from the amino acids, acid amides, etc., so far as, *e.g.*, solubility in water is concerned.

Again, amino acids,[28] purine bases,[29] pyrimidine derivatives[30] and other[31] non-protein substances have directly been isolated at room temperature from a considerable number of soils,—namely, from weak (2 per cent.) sodium hydroxide soil extracts. Under these conditions of the isolation of the above compounds hydrolysis of protein substances cannot very well be assumed.

The chemistry, then, of the organic nitrogenous compounds in soils can at present broadly be stated as follows: Under the action of proteolytic enzymes, micro-organisms, or chemical means, the proteins are decomposed—probably through the stages of albumoses, peptones, and polypeptides—chiefly to diamino acids, mono-amino acids, and acid amides. In addition to these products, there results also nucleic acid, in the case of nucleoproteids, which latter, on decomposition, yield nucleins, and, further, proteins on the one hand, and purine bases, pyrimidine derivatives on the other. Furthermore, some non-protein sub-

[28] *Journ. Biol. Chem.*, vol. viii, No. 5, p. 381 (1910).

[29] *Journ. Biol. Chem.*, vol. viii, No. 5, p. 385 (1910).

[30] *Ibid.*

[31] Ann. Report Hawaii Agr. Exp. Sta., p. 37 (1906); *Journ. Amer. Chem. Soc.*, 34, 99 (1912).

stances like acid amides and amino acids, as stated already, come as such into the soil with certain plants.

As to the accumulation in the soil of the nitrogenous compounds, it can safely be stated that the compounds which are more resistant to the above-mentioned agencies will be found in the soil in larger proportions than the less resistant substances. The amino acids and acid amides cannot accumulate in the soil to any extent, because they are easily ammonified in it, as was shown in a recent publication.[32]

It does not make, however, much difference whether at any time the acid amides and amino acids are present in the soil in smaller or larger quantities, if only the higher complex molecules of the proteins and nucleoproteids have to pass through the stage of the acid amides and amino acids before their nitrogen can be transformed into ammonia.

The ammonia and nitrites, too, cannot accumulate in the soil, because of their ready oxidation to nitrates, which latter, again, are ordinarily encountered in soils in but small quantities, for the reason that they are eagerly taken up by plants, or leached out of the soil in case it is followed.

It is only soil nitrogen in its initial stage—proteins and nucleoproteids—that is commonly present in considerable quantities in the soil. The nitrogen in its final stage—nitrates—can, under certain conditions, accumulate in the soil. All other forms of nitrogen, both organic and inorganic compounds, represent transition stages and seem to be present in soils in but inconsiderable proportions. The acid amides and amino acids represent some of the organic nitrogenous compounds out of which ammonia is immediately formed.

It thus can be seen that many of the organic nitrogenous compounds represent a great and important source from which the available nitrogen—ammonia and nitrates—is formed. Consequently, the problem of the formation and utilization of the available soil nitrogen is one which is intimately connected with the question of the chemical nature of the organic nitrogen.

Schematically the chemistry of the soil nitrogen may be presented as follows:

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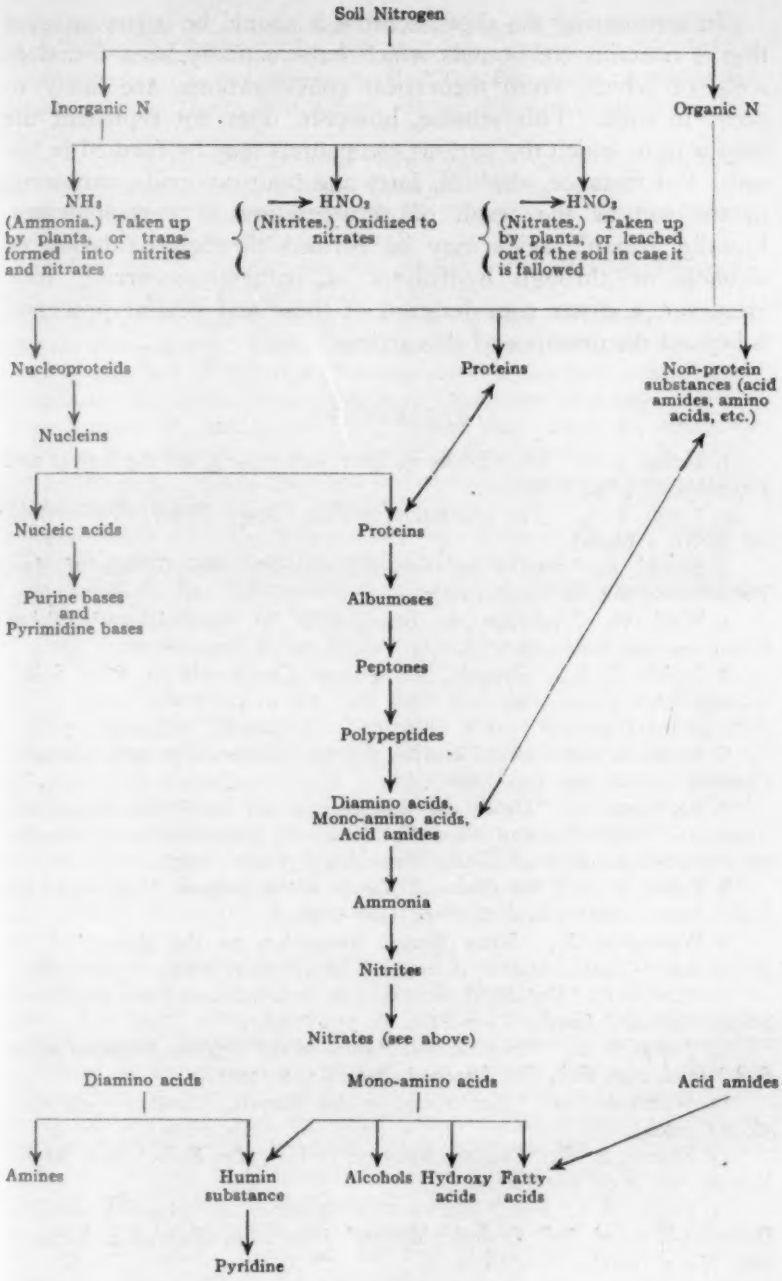
[32] Jodidi, S. L., original communications, VIII International Congress of Applied Chemistry, vol. 26, p. 119.


Soil Nitrogen
Inorganic N
Organic N
NH_3
(Ammonia.) Taken up by plants, or transformed into nitrites and nitrates
HNO_2
(Nitrites.) Oxidized to nitrates
HNO_3
(Nitrates.) Taken up by plants, or leached out of the soil in case it is fallowed
Nucleoproteids
Proteins
Non-protein substances (acid amides, amino acids, etc.)
Nucleins
Nucleic acids
Proteins
Purine bases and Pyrimidine bases
Albumoses
Peptones
Polypeptides
Diamino acids, Mono-amino acids, Acid amides
Ammonia
Nitrites
Nitrates (see above)
Diamino acids
Mono-amino acids
Acid amides
Amines
Humin substance
Alcohols
Hydroxy acids
Fatty acids
Pyridine

In considering the above scheme it should be borne in mind that it contains compounds which have actually been found in soils, or which, from theoretical considerations, are likely to occur in soils. This scheme, however, does not represent the only way in which the various compounds may be formed in the soil. For instance, alcohols, fatty and hydroxy acids, can occur in the soil as the result of fermentation of carbohydrates. Equally, organic acids may be formed through oxidation of alcohols or through hydrolysis of naturally-occurring fats. However, a closer consideration of these and similar processes is beyond the province of this article.

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22. Schulze, E., and Barbieri, J., "Ueber den Gehalt der Kartoffelknollen an Eiweisstoffen und an Amiden," *Landw. Vers.-Stat.*, 21, 86 (1878).

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IOWA STATE COLLEGE, Ames, Iowa.

The Specific Heat of Fibrous Materials. OTTO DIETZ. (*Wochbl. Papierfabr.*, xliii, 3119.)—The specific heats of the animal and vegetable fibres vary only slightly from one another, and are between the limits 0.319 and 0.331, so far as cotton, silk, wool, linen, hemp, wood-pulp, artificial silk, etc., are concerned. The mineral fibres have lower specific heats: thus, that of asbestos is 0.251 and that of glass-wool is 0.157. The specific heat is practically unaffected by temperature or content of moisture.

Helium in Gases from Springs. C. MOUREU and A. LEPAPE. (*Comptes Rendus*, clv, 197.)—While the rare gases argon, krypton, xenon, and neon seem to occur in natural springs approximately in quantities of the same order as in the atmosphere, the percentage of helium is sometimes far higher, and some springs in the Côte d'Or contain 10 per cent. of helium in their total gas content, consisting of nitrogen and the rare gases. The Source Carnot at Santenaz yields 17,845 litres of helium per annum. This helium might be "young" (*i.e.*, liberated as it is formed) or "fossil" (*i.e.*, liberated after long accumulation). The first assumption would require the disintegration of 91 tons of radium or of 500 million tons of pitchblende per year for the production of the helium, hence this seems out of the question.

Foreign Lighting Practice. DR. L. BELL. (*Elec. World*, lx, 17, 875.)—In the early days of the metallic filament lamp and of the flame arc the United States was behind Europe, but at present has quite caught up. When the long-burning flame arc appeared in Europe three or four years ago the work of development was taken up here, and this country soon reached an equality. Metallic filament lamps have been largely developed abroad, especially for small units and lamps of high voltage. The 15-watt tungsten lamp for 110 volts was quickly followed by a similar development here. The latest foreign development is a wire-drawn tungsten lamp for voltages from 90 to 120, consuming only 7 watts and giving 5 candle-power. Abroad, as here, arc lamps with the long-burning flames are making progress, but the short-burning flame still holds an important place. One type of short-burning flame, not known to any considerable extent here, seems to have a considerable usage,—*i.e.*, the flame lamp at low wattage, say 300 or less, and working at a voltage that permits a pair of lamps to be worked in series on the ordinary low-tension circuit. Then should be mentioned the cadmium amalgam quartz arc, which works very similarly to the ordinary quartz arc, but metallic cadmium held vaporized by the arc is the chief source of light, just enough mercury being added to bring the color from the reddish of cadmium to a pretty good white. The most interesting lamp of foreign origin is the neon tube, on the principle of the Moore light, but using neon as the illuminescent gas. The color is a beautiful deep orange, and gives an efficiency considerably better than any other gas hitherto tried—as low, it is claimed, as 0.8 watt per mean spherical candle-power for a tube about twenty feet long.

The Origin of β and γ Rays from Radioactive Substances. E. RUTHERFORD. (*Eng.*, xciv, No. 2442, 549.)—In all cases one α particle is expelled per atom, with the single exception of thorium C, which gave two α particles of different velocities per atom. The β rays were very complex, according to Hahn and Meitner and others. In a magnetic field a single β ray would be spread out into a fan with curved lines, and when the photographic plate was placed sideways each of these lines appeared as a circle. A substance might give upwards of 15, even 30, radiations; and if they were all simply β rays the facts were difficult to explain. He agreed with Bragg, that the β rays, in escaping and passing through different regions, had different amounts of energy abstracted from them, and he gave simple algebraic formulæ connecting these rays from RaB and RaC. Some β rays were converted into γ rays; the β rays were changed by passing through matter, whilst the γ rays were the characteristic rays of the radium atom. Professor Bragg agreed that the energy diminished by leaps. Professor Soddy thought the γ rays seemed to come from the slow rather than from the fast β rays.

NOTE ON THE CONSTRUCTION OF THERMOPILES FOR MONOCHROMATIC ILLUMINATORS.*

BY

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ONE of the most difficult problems that confronts experimenters who use light stimuli is the measurement of the energy value of these stimuli.

High intensity and high spectral purity are incompatible. The common mistake made by instrument makers is the construction of a spectroscope (illuminator) with a high dispersion and a low light-gathering power. The lenses may be $f/6$ when they ought to have an aperture of $f/3$. The result is what one would expect (judging from the standpoint of the victim who attempts to measure the energy in the spectrum of any of our common light sources), viz.: the attempt to measure the energy is practically a failure, especially in the violet and in the ultra-violet. This explains why, in marked contrast with the infra-red, the visible spectrum has gone all these years unmeasured. Much pioneering work is needed in the visible and in the ultra-violet, and, until we have some idea as to whether it is worth while to use high dispersion, it seems desirable to sacrifice spectral purity in order to get a start in the radiation measurements.

THE SPECTROSCOPE.

The spectroscope constructed for the purpose is a simple device, the main feature being that it is entirely enclosed to exclude extraneous light. Two pairs of telescope lenses are provided: (1) a pair of triple-achromatic lenses made by Zeiss, 6 cm. in diameter and 18 cm. focal length, and (2) a pair of plano-convex lenses of quartz, 6 cm. in diameter and 18 cm. focal length. Combined with a 60° quartz prism the latter is used in the ultra-violet. There is much less loss of light in the simple (quartz) lenses, and the change in focal length is of minor im-

* Communicated by the author.

portance, especially when measuring spectral lines. This is owing to the fact that the focal length of the collimating lens is kept fixed, so that the same amount of energy, of all wave-lengths, emerges from the collimating lens and passes through the prism to the objective lens. In passing from the extreme red to the extreme ultra-violet the aperture increases from *f/3* to about *f/2.5* as the result of refocusing, but the objective transmits to the thermopile slit the same proportion of light, of all wave-lengths. Theoretically of course, the focal length of the collimator should also be varied so that all wave-lengths will leave the collimator in parallel rays, but this is of minor importance.

THE THERMOPILE.

In order to measure correctly the energy in the spectrum, when the focal length has to be varied, it is necessary to use a receiver that is completely opaque to the incident radiations. It was to satisfy this requirement that the bismuth-silver thermopile,[1] with a completely opaque receiver, was designed. Silver wire was used because it contributes but very little in resistance and it is easy to manipulate. As mentioned in the above-cited papers, iron has a high resistance, it rusts off easily, and for these reasons the writer does not recommend its use.

The slight additional electromotive force gained in a bismuth-iron thermopile may be obtained in a bismuth-silver thermopile by adding several more thermo-junctions in the same length occupied by the bismuth-iron junctions. This is advantageous, for the sensitivity is proportional to the square root of the exposed surface, and it is desirable to place as many junctions as possible within a given area (length of exposed surface, for the width is quite predetermined by the dispersion, and hence the width of the slit). For example, suppose we use individual receivers 1 mm. wide and desire to build a receiver 4 mm. long. If we use four individual receivers 1 mm. long the galvanometer deflection will be four times that caused by a single receiver 1 mm. long. If we use but a single receiver 4 mm. long, then the deflection is only twice $(\sqrt{4})$ that of a receiver 1 mm. long. Of course, the

[1] JOURNAL FRANKLIN INSTITUTE, December, 1911, and February, 1913; *Bulletin Bureau of Standards*, 9, p. 7, 1912.

latter is the simpler to construct, and that is where the commercial instrument builder makes a mistake. It is not sufficient to use bismuth-iron, which has a slightly higher thermal electromotive force, in order to manage with a less number of thermo-junctions, as will be shown presently.

The following tests were made to determine the relative sensitivity of bismuth-iron (steel) and bismuth-silver thermopiles:

To one end of a bismuth wire, 0.1 mm. in diameter and 5 mm. in length, was soldered an *iron* wire 0.0308 mm. in diameter, and to the other end was soldered a *silver* wire 0.0308 mm. in diameter. In both cases the diameters of the wires are very close to the theoretical values required for maximum sensitivity. The ends of the silver and of the iron wire were tinned (as described in the previous paper), in order to obtain a thorough junction with the bismuth. To each junction was welded a tin receiver 2 by 1 by 0.025 mm. (as actually used in practice), which was painted with lamp-black and then blackened still more with soot from a sperm candle. Such a pair of junctions was then enclosed in an air-tight receptacle to eliminate air currents. A standard incandescent lamp, with a shutter in front of it, was placed at a distance of about 1.5 m. from this thermo-element, and the receivers were exposed alternately (also simultaneously for the differential effect) to the standard source of radiation. The result of several such tests showed that the radiation sensitivity of the bismuth-iron (steel) junction was about 22 to 23 per cent. higher than that of the bismuth-silver junction. In other words, using the same sized receivers it would require only about four-fifths as many bismuth-iron junctions as it would require bismuth-silver junctions in constructing a thermopile. But, as it will be shown presently, the resistance of the bismuth-iron thermopile will be almost three times as great as that of a bismuth-silver thermopile, which is of the order of 8 to 9 ohms. Now, the physical laboratories are usually equipped with low-resistance galvanometers, and it will be necessary to construct new ones having a resistance comparable with the bismuth-iron thermopile, or it will be desirable to use a bismuth-silver thermopile.

A test was made of the radiation sensitivity of iron wires 0.0308 mm. and 0.0418 mm. in diameter (joined to bismuth wire 0.1 mm. in diameter; with receivers as in the Bi-Fe and Bi-Ag

test) to determine whether the thicker wire, which has only one-half the resistance of the 0.03 mm. wire, can be used. The test showed that the 0.03 mm. wire (iron), against bismuth 0.1 mm. in diameter, had a radiation sensitivity 9 to 10 per cent. higher than the 0.04 mm. iron wire, so that what is gained in eliminating the resistance is lost in radiation sensitivity.

The "iron" wire usually obtainable on the market is steel having a thermo-electric power of about 11 microvolts at 20°. The particular sample (0.03 mm.) tested against bismuth (0.1 mm.) had a thermo-electric power of 83 microvolts, while a bismuth-silver thermocouple had a thermo-electric power of 75 microvolts. Another sample of bismuth (0.1 mm. in diameter) against this same sample of silver had a thermo-electric power of 81 microvolts. A sample of bismuth 0.15 mm. (against silver) gave 86 microvolts, which is close to the value (89 microvolts, mentioned in the previous paper) obtained on another sample of 0.15 mm. wire. Apparently the thick wires give a higher electromotive force, which is probably to be expected from the experiments of Matthiesen. These tests show the necessity of examining the different samples of bismuth wire in order to be able to select the one giving the highest electromotive force.

The samples of iron (steel) wire 0.0308 mm. in diameter were found to have a resistance of 0.21 to 0.23 ohm per millimetre. The bismuth wire 0.1 mm. in diameter had a resistance of 0.10 to 0.11 ohm per millimetre. It requires about 4 mm. of bismuth (averages 0.41 to 0.43 ohm) per thermo-junction. The resistance of the silver wire is negligible. Two thermopiles of twenty elements each of bismuth-silver had a resistance of 8.3 and 8.6 ohms respectively. A different sample of bismuth wire would, of course, give a slightly different result (*e.g.*, another sample tested 0.12 ohm per mm. Its thermo-electric power against silver was 77 microvolts). Turning now to the question of the substitution of iron for silver, it is to be noticed that the shortest possible length that can be used is about 2 mm., or 4 to 5 mm. for the two pieces joined to the ends of the bismuth wire. This makes a resistance of 0.8 to 1.0 ohm; to which must be added 0.4 ohm for the bismuth, so that the resistance is 1.2 to 1.5 ohms per thermo-element. Since from four-fifths to three-fourths as many elements will be required as in the bismuth-silver thermopile of 20 junctions, in order to attain the same

radiation sensitivity, the resistance of a bismuth-iron thermopile of 15 (or 16) junctions will be from 22 to 24 ohms.

Owing to the greater difficulty in annealing and tinning the iron wire, which requires an acid cleaner in order to insure good contact in making the soldered joint; also owing to rusting, and to the undesirability of using corrosive substances (the material commonly used in soldering is zinc chloride) in soldering the junctions, the bismuth-silver thermopile is found to be the easier to construct and it promises to be the more long-lived. Its novelty is the completely opaque receiving surface, which makes it as useful as a bolometer (which it equals in sensitivity) with none of the disadvantages of the latter. By exhausting the air to 0.1 mm. with an oil pump the sensitivity is doubled. By attaching the receivers to the junctions with shellac instead of solder the radiation sensitivity is reduced about 9 per cent.

The foregoing tests were made to satisfy myself as to a claim made that the bismuth-iron thermopile is a far more sensitive instrument. The results show that, as found in the previous paper, by adding several more junctions of bismuth-silver in the space occupied by a bismuth-iron thermopile it will not be inferior to the latter in its radiation sensitivity. The writer therefore feels no necessity for changing the conclusions arrived at in the preceding paper, as to the relative merits of those two thermopiles. The choice seems to be a personal one, with low resistance, ease of construction, and lasting qualities in favor of the bismuth-silver combination. At present an attempt is being made to have annealed wire drawn from the Hutchin alloys, Bi + 5 per cent. Sn and Bi + 3 per cent. Sb, which have a much higher thermo-electric power than pure bismuth. Whether the increased resistance justifies their use remains to be determined.

WASHINGTON, D. C., March 14, 1913.[2]

[2] Since writing this, R. Fuess, Steglitz-Berlin, has informed me that he will use this thermopile with his new high intensity monochromator. This thermopile, mounted upon an appropriate stand, may also be obtained from the Cambridge Scientific Instrument Company, Cambridge, England.

Tantalum Electrodes. O. BRUNCK. (*Chem. Zeit.*, xxxvi, 1233.)—Metallic tantalum, which was originally manufactured solely for use in metal filament electric lamps, has recently been introduced as a substitute for platinum for certain purposes. Shaped articles of tantalum are sold at M. 2.50 per gramme, about $17 per ounce. Below 200° C. tantalum is not attacked by air nor oxygen nor acids, with the exception of concentrated hydrofluoric acid; it is not attacked by *aqua regia*. Aqueous solutions of alkalies do not attack it, but fused alkalies do. When heated, it oxidizes at a temperature considerably below red heat. It is very useful for surgical and dental instruments, and has been found very suitable as a substitute for platinum for electrodes, especially for electro-analysis. As cathode, tantalum can replace platinum in all cases, but when used as anode it becomes coated with a badly-conducting film of dark-blue tantalum oxide, and for this purpose it is necessary to coat it electrolytically with a thin deposit of platinum before use. When used as cathode for the electrolytic determination of metals, tantalum possesses this advantage, that the deposits can be removed from the electrode by dissolving in acid or *aqua regia*. Zinc and cadmium show no tendency to alloy with tantalum when deposited thereon. Another advantage of tantalum as compared with platinum, apart from the difference in price of the two metals, is that tantalum has a specific gravity of only 16.6, compared with 21.48 for platinum, hence less metal is needed to make articles of a given size. Tantalum electrodes could also be used in place of platinum in the electrolysis of alkali chloride solutions for the manufacture of hypochlorites or bleaching solutions.

Pinch Effect Furnace. CARL HERING. (*Met. Chem. Eng.*, x, 196.)—After repeated runs on bronze, steel, and steel alloys, the holes containing the resistor part of the bath show no increase in size; on the other hand, in some cases a decrease was noted, due to a hard, smooth, black coating, presumably of oxides and other impurities combining with the magnesite. If any change should occur it can be compensated by regulating the transformers to give a higher amperage at a lower voltage. The freezing of the charge does no harm, for the furnaces have been repeatedly started in the morning on the remains of the frozen charge of the previous day.

Asbestos in the United States. J. S. DILLER. (*J. Can. Min. Inst.*, xiv, 93.)—This is a geological paper and deals with the nature of the asbestos deposits of the United States. Only two of the four different types of deposits are worked commercially, viz.: (1) cross-fibre veins of chrysotile asbestos in serpentine in Vermont; and (2) mass-fibre amphibole asbestos in Georgia and Idaho. The production of asbestos in the United States is over 3000 tons, or about 5 per cent. of the production in Canada, which constitutes by far the largest part of the world's total output.

THE MEASUREMENT OF THE TRUE STATIC PRESSURE IN A MOVING FLUID—APPLICATION TO AN AËROPLANE BAROGRAPH.

BY

DR. A. F. ZAHM.

As yet no very convenient instrument or method, of general applicability, for finding the precise altitude of an aëroplane in flight appears to be available. In some favored localities, as at Lake Keuka or Fort Myer, it is practicable to have accurate bench marks on the side of a steep hill, or on a lofty tower, from which to sight over the aviation course, and thus to observe precisely whether the machine has risen above a prescribed elevation. This method serves in altitude tests for pilot licenses when but a single predesignated height has to be measured; but, besides being restricted to favored localities, it cannot be practically used to give a continuous story of the altitude from instant to instant. An elaborate system of triangulation can be employed, with some accuracy, for flights over a limited field in any locality; but it is very tedious in all cases, and is inapplicable to cross-country voyages. Various other methods may be suggested, but, aside from the barometric one, none of these have come into general practice.

In the use of the recording barometer, or barograph, curious errors arise, which may perplex or baffle the observer charged with the responsibility of taking the altitude; and, indeed, may not a little vex him when some great trophy, cash prize, or world's record is at stake. In principle the barograph is supposed to reveal the altitude of flight by recording continuously and accurately the pressure, from which the observer computes the elevation according to an assumed law connecting the altitude and atmospheric pressure. We need not tarry over the sensibilities of this law to every transient fluctuation of moisture, of temperature, and of aërial turbulence, but allow that their effects have been circumvented or minimized.

The task now is to obtain true pressure records. We will suppose that the instrument is so suspended on the flier that the recording pen will not, by shaking or otherwise, blur the record.

We will suppose that the lag of the pen due to friction or fatigue of the straining metal of the barograph cistern has been obviated or perfectly met by previous calibration; in a word, that the barograph record discloses the true pressure *within* the box, or case holding the instrument. Under these very favorable circumstances we may inquire what is the pressure in the air just outside the box.

The passive balloonist is not troubled by this query. He knows that, as he drifts with the tide of the air, the static pressure is identical inside and outside the instrument case. But on an aëroplane or motor balloon the air-stream rushes swiftly by the instrument case, and in general causes either suction or increase of pressure inside the case, where the barograph is mounted. One may put the case itself inside another box to avoid the air rush, but without avail; the larger box meets the air rush, suffers a consequent change of internal pressure, and so advantages nothing. The question then is to correct for this change of pressure, or, better still, to obviate it by use of an instrument case whose internal pressure is unaffected by the air rush. To design such a case is substantially the question before us. Let us first have a working principle on which to base the design.

When any fluid is in steady motion relative to an immersed solid, it appears to flow past the body in definite stream-lines. If the flow be uniform, the stream-lines, or paths of the individual particles, are parallel everywhere in the fluid except in the region where it courses round the body. In the region of the body the stream-lines, if rendered visible, are, in general, seen to crowd more closely together in some places, and to diverge more or less in other places, as illustrated in the accompanying figure (Fig. 1). Now, by a well-known theorem in fluid dynamics first proved by Bernouilli, the diverging of the stream-lines, at any point in a level stream of liquid, signifies an increase of pressure there, while a crowding signifies diminution of pressure. If, therefore, any fair figure immersed in such a liquid stream have a portion of its surface invested by stream-lines unchanged in relative spacing from that they enjoyed in the undeviated current, that portion of the surface must sustain the same pressure as prevails in the unchecked stream at the same level. The free air is, of course, not sufficiently incompressible to comply strictly with Bernouilli's theorem; but for ordinary

speeds of transportation it does so with ample approximation for the purpose in hand. This has been proved mathematically and experimentally elsewhere by the present writer.[1]

Having, then, such a fair figure in a uniform level stream, say of air, if its surface be perforated at any point of unchanged stream-line spacing, the pressure within must, provided there occur no material leakage, be the same as in the undeviated current. Hence if such figure form the barograph case, or be hermetically connected therewith, the instrument will sustain and, other things perfect, truly record the static pressure of the general and undisturbed air-stream.

Starting with this basic principle, an indefinite number of figures having "neutral" spots, or places of unchanged pressure,

FIG. 1.

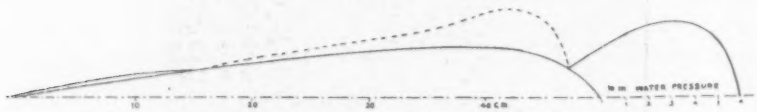
Stream-lines about a fixed cylinder transverse to a uniform stream of air.

on their surface, may be rationally designed or discovered by systematic experimentation in a uniform current. If the inventor can recall from his visual experience, or rationally devise, a surface which at some spot shall have unstrained flow,—*i.e.*, unstrained spacing of the stream-lines,—he can use that spot, duly perforated, for a collector of the true static pressure desired. A thin plane moving edgewise through the fluid, a thin open tube moving endwise, a nicely pointed narrow cylinder or closed pipe moving dart-like, obviously has some such neutral points well back of the entering edge or point. A sphere, a torpedo form moving axially, has a ring of neutral points which, as shown by Finzi and Soldati (Fig. 2), can be located experimentally. And so for many other figures submerged in a uniform stream.

[1] *Physical Review*, Dec., 1903.

In practice the air rush past a barograph, especially on a slow flier in a turbulent atmosphere, may be far from uniform; for the apparent fluctuation of speed and direction, referred to a body advancing through a fluid, is inversely as its speed. If the fluctuations be considerable, the above-mentioned shapes may not have fixed neutral spots on their surface, and consequently may not transmit the true static pressure. For example, the thin plane above mentioned experiences the true static pressure of the medium, while advancing exactly edgewise; but, when striking the air at a slight angle, sustains marked suction on the lee side, and compression on the other. So also for the pointed rod or tube. Of course, these shapes can be pivoted so as always to meet the wind directly. But this precaution may be rendered unnecessary by use of guiding blades; for, as the writer has found in wind-tunnel experiments, when the air blows through

FIG. 2.



Distribution of air pressure on torpedo-shaped model, moving large end first, ten metres per second. Surface pressure in millimetres of water, at ten metres per second, measured perpendicular to surface. Heavy lines indicate excess over normal atmospheric pressure; dotted line indicates defect of pressure.

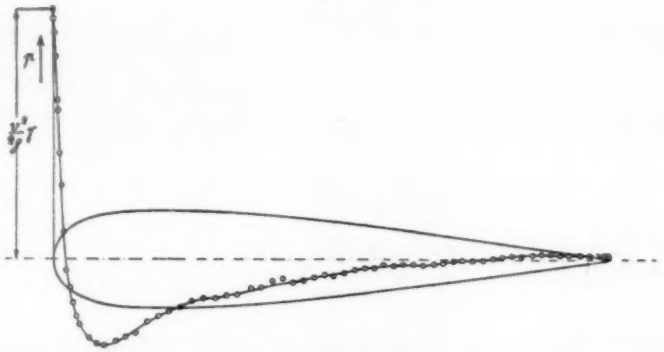
a honeycomb of guiding blades, say of thinnest steel, there is very slight disturbance of the stream-line spacing, even when the wind varies considerably in direction. And so in general for parallel thin surfaces placed edgewise to the general direction of the current. An open tube with thin walls is a good example; its inner surface well back from the mouth should sustain nearly the true static pressure, and therefore may well be perforated and connected by suitable tubing to the instrument case of the barometer.

There is a "wire sandwich" collector alleged to be competent to gather and transmit the true static pressure, whatever the directional fluctuation of the wind. It consists of two thin circular discs pressing between them a wire screen which projects slightly beyond their edges. This sandwich is alleged to experience at its internal centre the true static pressure of the wind, and hence to be suitable for tapping and connection with a gauge intended to show the true pressure, whatever the angle of impact against its exterior. The writer cannot endorse

this claim, for the aërodynamic reason that when a circular disc encounters a current at a sufficiently large angle of incidence its entire periphery is subject to suction; hence in the case of the sandwich there must, for such angle, be a deficit of true static pressure all over its interior.

The infinitude of practical devices which can be constructed in some way involving the foregoing considerations may be divided into two general classes: those placing the barograph in a stream-line case having on the outer surface some neutral area which can be perforated to transmit inwardly the true pressure; those having a true-pressure nozzle, or collector, suitably connected with the barograph case, wherever it may be placed.

FIG. 3.



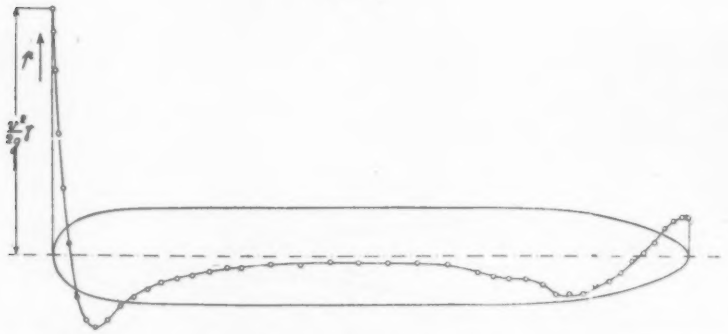
Air-pressure distribution on balloon model moving large end first. Minimum pressure toward stern. Ordinates represent air pressure.

For example, the accompanying figures (Figs. 3 and 4), taken from Fuhrmann's paper on pressure distribution on balloon models, show a form which, in a uniform current, is fairly suitable for either a barograph case or a pressure nozzle connected therewith by suitable tubing. As the distance of the dots from the axial line of the diagram of the models indicates the excess or deficit of pressure on the corresponding parts of the surfaces, it is seen, by scaling the diagram, that the mid or aft regions of the surfaces have pressure which, if not actually zero, differ from the true static pressures of the wind by less than five per cent. of that shown at the point of the prow, where it is always a maximum. The true-pressure case, or nozzle, would, of course, have to be placed before the aëroplane far enough to avoid the pressure disturbance caused by the flier itself. Doubtless still better

forms for the purpose in hand could be found for a current of varying direction, by experiment in a wind tunnel, and this might form a suitable task for some college student of physics or engineering.

The foregoing inquiry was prompted by a former chairman of the Contest Committee of the Aëro Club of America, who wished to know how to avoid or evaluate the errors of an aëroplane barograph caused by the rush of air past his instrument case. Having indicated how to avoid or minimize the errors, we may now attempt to evaluate them for certain conditions. Assuming the worst possible condition, let the barograph case set squarely to the wind, and have an ample per-

FIG. 4.



Air-pressure distribution on balloon model moving large end first. Minimum pressure at sides. Ordinates represent pressures on corresponding parts of surface.

foration in the centre of its front face. Then, as is well known in fluid dynamics, the excess of pressure inside the case will be that due to a vertical column of homogeneous air of a height equal to the "velocity head," or height to which the aëroplane, as a projectile in vacuo, would rise vertically with its actual speed. This height is the greatest altitude error the instrument can make in such manner; and it is not inconsiderable.[2] For, if the speed of flight be sixty miles an hour, the velocity head is about forty yards; and if the speed be twice this, the head is four times forty yards, since the head increases as the square of the velocity.

[2] By suitably locating an aperture on the side of a model, suction intensities exceeding in numerical magnitude the "velocity head" have been found by some experimenters.

Under these conditions, if the barograph record be read when the aëroplane is flying at any altitude, and again when resting at the same altitude, the readings will indicate that the machine in flight was lower than when at rest, though both altitudes were identical; or, in particular, if an aëroplane having a speed of sixty miles an hour should rise to a height of fifty yards above the place where its stationary zero trace began, its barograph would indicate an altitude increment of ten yards instead of fifty. But this error could be obviated by taking the zero trace in full flight at a known level, providing the speed be the same at both levels.

Owing to the difference of speed of an aëroplane at two vastly different levels, the barograph errors at the two levels, due to the air rush, do not cancel each other. At a given angle of flight, as is well known, the square of the speed of sustentation varies inversely as the density; and, therefore, the velocity head, which varies as the square of the speed, must vary inversely as the density. Hence the errors in the altitude records at the two levels are inversely as the densities. If, for example, the sea-level speed of a machine be sixty miles an hour, the error in the altitude record will be forty yards at that level and fifty yards up where the density is eighty per cent. of that at the sea-level. The differential error is thus ten yards for the difference of the two levels, which is slightly over one mile, as indicated by meteorological tables. But this is the maximum error for that altitude change. If the barograph case were given a more favorable orientation the error would be much less. And if it were placed inside a shield of the balloon model form here shown, the differential error would, if not actually zero, be less than five per cent. of ten yards, or, say, a half of one yard. Compared with the barograph errors due to fatigue and other causes, this item should not greatly perturb even a conscientious chairman of an aëronautic contest committee.

JANUARY, 1913.

Aeroplanes in Warfare. ANON. (*Sci. Amer.*, cvii, 19, 402.)—A number of aëroplanes were used with great success by the Italians in their war in Tripoli. On August 24, 1912, Lieutenant Manzini fell into the Mediterranean and was drowned while reconnoitring. Turkey has more than a dozen officer aviators, who have learned to fly in England and France. They use Bristol, Blériot, and R. E. P. monoplanes and Farman biplanes. The Servian army has three aviators, with machines of the Blériot type; and the Roumanian and Bulgarian armies have strong forces of aviators with various types of aëroplanes. There are several good Montenegrin military aviators, and the Greek officers who learned at the Farman school in France are excellent flyers. The Bulgarian army has more than six Bristol monoplanes, while at the Roumanian army manœuvres, Mr. C. H. Pixton made some good demonstration flights with one of these English machines. Ten Italian and Russian aviators, including Abramovitch (who recently flew from Berlin to St. Petersburg) and Nicholas Popoff, were engaged by the Servians and Bulgarians to scout for the allied armies. The two Russians used Wright biplanes. Popoff made several flights in the vicinity of Adrianople, and while soaring over this besieged city was struck by a shrapnel shell and fell to his death. A Farman biplane was used by the Greeks for scouting before the invasion of Turkey was decided upon, and a radius of fifty miles of country was flown over.

Hydraulic Lime. G. HENTSCHEL. (*Tonind. Zeit.*, xxxvi, 1843.)—In calculating the hydraulic modulus

$$\frac{CaO + MgO}{SiO_2 + R_2O_3}$$

of a sample of hydraulic lime, any undecomposed calcium carbonate and insoluble silica must be taken into consideration by subtracting the amount of lime combined with carbon dioxide, and the amount of silica which is not soluble, from the respective constituents as they appear in the formula. The nearer its hydraulic modulus approximates to that of Portland cement (1.7 to 2.1), and the smaller the amounts of insoluble residue and calcium carbonate which it contains, the greater is the value of a hydraulic lime. It was found that by raising the temperature of calcination, so as to decompose the calcium carbonate completely without dead-burning the lime, a stronger-setting hydraulic lime was obtained, yielding sand-mortars which had 2½ times the crushing strength of sand-mortars prepared from the same raw materials calcined at a lower temperature. The addition of 2 per cent. of stucco plaster, or of 2½ per cent. of raw gypsum, greatly increased the crushing strength of hydraulic lime mortars, especially when these were exposed to atmospheric conditions only.

RECENT DEVELOPMENTS IN STEAM TURBINES.*

BY
H. T. HERR,
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XXVII. The following formula, a proof of which will be given later, serves to calculate the extent to which condensation takes place during adiabatic expansion, and so allows the relation of pressure to volume to be determined.

Before expansion, let the initial dryness of the steam be q_1 and its absolute temperature T_1. Then if it expands adiabatically until its temperature falls to any value T, its dryness after expansion is

$$q = \frac{T}{L}\left(\frac{q_1 L_1}{T_1} + \log_e \frac{T_1}{T}\right)$$

L_1 and L are the latent heats (in thermal units) of one pound of steam before and after expansion respectively. When the steam is dry to begin with, $q_1 = 1$.

This formula, which is applicable, with proper values of L, to any vapor, may be called the equation of adiabatic expansion or compression. It does not directly give the relation of pressure to volume, but it allows the dryness at any stage of the process to be calculated, and from that (together with the fact that the part which remains in the condition of vapor is saturated) it is easy to find the volume which the mixture will fill when its pressure has changed to any assigned value.

Suppose, for instance, that originally dry saturated steam at an absolute pressure of 115.1 pounds per square inch is made to expand adiabatically. Its original volume per pound is 3.843 cubic feet, and its temperature is 338° Fahr. To find the relation of pressure to volume at any stage in expansion: Take any value of the pressure reached by expansion, say 20.8 pounds per square inch absolute. The expanded temperature is 230° Fahr. by steam tables. This gives the values of quantities in the adiabatic equation above:

*Continued from page 412.

$$q_1 = 1$$
$$T_1 = 338 + 461 = 799$$
$$T = 230 + 461 = 691$$
$$L_1 = H_1 - h_1 = 1185 - 308.7 = 876.3$$

Hence,
$$q = \frac{691}{953.4}\,\frac{1 \times 876.3}{799} + \log_e \frac{799}{691} = 0.9$$
$$v = qV + (1 - q)\,w$$
$V = 19.18$ cubic feet from the steam tables
$$v = .9 \times 19.18 + .1 \times .017 = 17.26$$

Since $w = .017$ cubic foot

Wet steam follows approximately the law expressed by the equation pv^n = constant where n varies directly as q, as illustrated in the following table:

$q = 1$	.95	.9	.85	.80	.75	.7
$n = 1.135$	1.13	1.125	1.12	1.115	1.11	1.105

XXVIII. To deduce the expression for the work done by Carnot's engine using steam for a working substance, let it be

FIG. O.

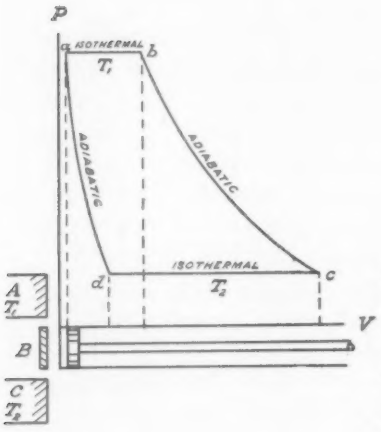
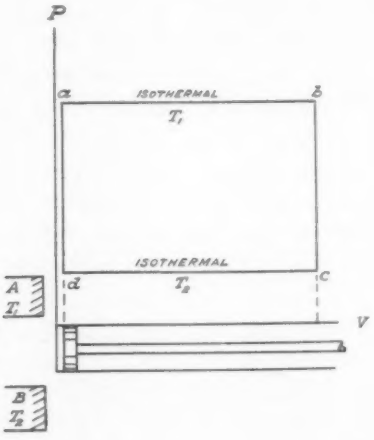


FIG. P.



supposed that Fig. O represents, as before, a long cylinder composed of non-conducting material, except the head, and fitted with a non-conducting piston; also an indefinite source of heat A at some temperature T_1. A receiver of heat or a condenser C at some lower temperature T_2, also a non-conduct-

ing cover B. Suppose the cylinder contains one pound of water to begin with, at temperature T_1:

(1) Apply A to the end of the cylinder and allow the piston to move outward under constant pressure p_1, which corresponds to the temperature T_1. The water will take in heat and be converted into steam, expanding isothermally at temperature T_1. This part of the cycle is represented on the diagram Fig. O by the line $a - b$.

(2) Remove A and apply B. Allow expansion to continue adiabatically with falling pressure until the temperature falls to T_2. The pressure will then be p_2, corresponding in the steam table to T_2, which is the temperature of the cold body C. This adiabatic expansion is plotted in the figure by the curve $b - c$.

(3) Remove B and apply C and compress. Steam is condensed by the rejection of heat to C. The action is isothermal, and the temperature remains T_2. Let this be continued until a certain point d is reached, after which adiabatic compression will complete the cycle.

(4) Remove C and apply B. Continue the compression, which is now adiabatic. If the point d has been properly chosen, the cycle will be completed by restoring the working fluid to the state of water at temperature T_1.

Since the process is reversible, and since heat is taken in only at T_1 and rejected only at T_2, the thermal efficiency is

$$e = \frac{T_1 - T_2}{T_1} = \frac{W}{Q}$$

Therefore

$$W = Q\left(\frac{T_1 - T_2}{T_1}\right)$$

There are in the process $q_b - q_a$ pounds of water turned into steam; therefore, the amount of heat supplied is equal to

$$L_1 (q_b - q_a)$$

Substituting in the above equation this value for Q:

$$W = L_1 \frac{(q_b - q_a)(T_1 - T_2)}{T_1}$$

If the action so described could be realized in practice, an ideally perfect steam engine using saturated steam could be constructed. Like any other perfect heat engine, an engine of this

kind has an efficiency depending upon the temperatures between which it works, and upon nothing else. The fraction of the heat supplied to it, which such an engine could convert into useful work, would depend simply on the two temperatures, and therefore on the pressures at which steam was produced and condensed respectively.

The temperature of condensation is limited by the consideration that there must be an abundant supply of some substance to absorb the rejected heat. Water is generally used for this purpose, so that T_2 has for its lower limit the temperature of the available water supply. The higher temperature T_1 and pressure p_1 are limited in a practical way to the strength of materials and ability to operate an engine under high temperature and pressure conditions. A steam engine under the most favorable circumstances comes very far short of taking full advantage of the high temperature at which heat is produced in the combustion of coal, because steam pressures in boilers are generally kept somewhere within 200 to 250 lbs. per square inch, the temperature of the steam corresponding to this pressure being somewhere in the neighborhood of 400° Fahr. From a thermodynamic standpoint, the worst thing about a steam engine is the irreversible drop of temperature between the furnace and the boiler. The combustion of fuel supplies heat at a high temperature, but a great part of the convertibility of that heat into work is sacrificed by the fall in temperature which is allowed to take place before the conversion into work begins.

If the temperature of condensation be taken at 60° Fahr. as a lower limit, the efficiency of a perfect steam engine using saturated steam would depend on the value of the absolute pressure of production of steam as follows:

P_1 in pounds per square inch.....	40	80	120	160	200
Highest ideal efficiency.....	.284	.326	.350	.368	.381

As a contrast to the ideally perfect steam engine, consider the cyclic process occurring in the early engines of Newcomer in which steam is used non-expansively, or rather such a process as would have occurred if the engine had its cylinder made of a perfect non-conductor of heat and other conditions as recited in the description of Carnot's cycle.

Referring to Fig. P:

(1) Apply the hot body A and evaporate the water as before at pressure P_1 $(a - b)$. Heat taken in per pound of the working fluid $= L_1$.

(2) Remove A and apply the cold body C. This at once condenses the steam and reduces the pressure to $P_2(b - c)$.

(3) Compress at P_2 in contact with C until condensation is complete and water at T_2 is left $(c - a)$.

(4) Remove C and apply A. This heats the water again to T_1 and completes the cycle. Heat taken in $= h_1 - h_2$. Here the action is not reversible.

To calculate the efficiency:

$$\frac{\text{Work done}}{\text{Heat supplied}} = \frac{(P_1 - P_2)(V_1 - w)}{J(L_1 + h_1 - h_2)}$$

The values of this equation will be found to range from .067 to .072 for the values of P_1 stated above for Carnot's cycle when the temperature of condensation is 60° Fahr.

FIG. Q.

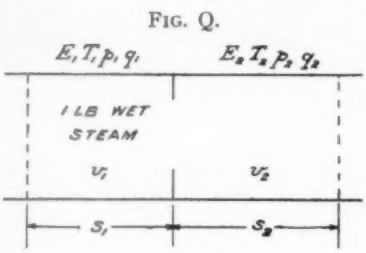
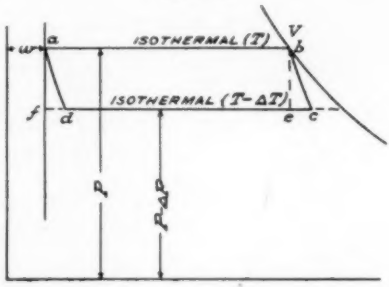


FIG. R.



The efficiency of an actual Newcomer engine is much lower than the figures given, because in every stroke of the piston a large part of the steam entering the cylinder is at once condensed upon the sides and the volume of steam supplied by the boiler was therefore much greater than the piston displacement.

XXIX. When steam is passed through a small orifice, it is sometimes unable to get through fast enough to keep up the pressure on the other side. There is, consequently, a drop in pressure and the steam is said to be throttled. When such a condition takes place in a closed vessel or a pipe through which steam is flowing, the steam is said to be throttled or wire-drawn.

Let Fig. Q represent a pipe of perfect non-conducting material with a restriction through which one pound of wet steam flows with energy E_1, temperature T_1, pressure p_1, quality q_1, vol-

ume v_1, and let the state of this one pound of wet steam after passing through the orifice be represented by energy E_2, temperature T_2, pressure p_2, quality q_2, volume v_2, and let p_1, p_2, and q_1 be known quantities, then T_1 and T_2 are known from the steam tables.

From the first equation of thermodynamics:

$$E_2 - E_1 = -W'' + W' + Q$$

but,

$$Q = 0$$

(since the pipe is a non-conductor of heat and any heat caused by friction of flow of the steam goes back into steam).

Let A = the area of a cross section of the pipe and s_1, s_2 the length of the pipe which the one pound of steam at the pressures and volumes specified would occupy; then,

$$\left.\begin{aligned} W'' &= (p_2 A)s_2 = p_2 v_2 \\ W' &= (p_1 A)s_1 = p_1 v_1 \\ E_2 &= E_{32} - p_2(v_2 - w) + J(h_2 + q_2 L_2) \\ E_1 &= E_{32} - p_1(v_1 - w) + J(h_1 + q_1 L_1) \end{aligned}\right\} \text{See XXIII.}$$

Subtracting,

$$E_2 - E_1 = -p_2 v_2 + p_2 w + J(h_2 + q_2 L_2) + p_1 v_1 - p_1 w, - J(h_1 + q_1 L_1)$$

But,

$$E_2 - E_1 = -W'' + W' = -p_2 v_2 + p_1 v_1$$
$$\therefore -p_2 v_2 + p_1 v_1 = -p_2 v_2 + p_2 w + J(h_2 + q_2 L_2) + p_1 v_1$$

Cancelling and solving for q_2,

$$q_2 = \frac{q_1 L_1 + h_1 - h_2 + \frac{(p_1 - p_2)w}{J}}{L_2}$$

But, $p_1 - p_2$ is very small, also w is very small.

Therefore the product of these two small quantities will be so small that it may be neglected.

$$\therefore q_2 = \frac{q_1 L_1 + h_1 - h_2}{L_2},$$

which is the expression for the dryness of steam after throttling.

To show that the dryness is greater after throttling than before,

$$q_2 = \frac{q_1 L_1 + h_1 - h_2}{L_2}$$

Adding q_1L_2 and subtracting q_1L_2 to and from the second member of the above equation,

$$q_2 = \frac{q_1L_2 - q_1(L_2 - L_1) + h_1 - h_2}{L_2} = q_1 + \frac{h_1 - h_2 - q_1(L_2 - L_1)}{L_2}$$

But,

$H_1 > H_2$, because $p_1 > p_2$
$\therefore h_1 + L_1 > h_2 + L_2$
$h_1 - h_2 > L_2 - L_1$
$\therefore h_1 - h_2 > q_1(L_2 - L_1)$

since $q_1 < 1$

$\therefore q_2 = q_1 +$ (some positive number)
$\therefore q_2 > q_1$

XXX. As pointed out in Carnot's cycle, an ideally perfect steam engine gives an indicator diagram with two lines of uniform pressure (isothermal) connected by two adiabatic curves. The heat taken in was L per pound of working substance, and, since the engine was reversible, its efficiency was

$$\left(\frac{T_1 - T_2}{T_1}\right)$$

from which it follows that the work done or area of the diagram was

$$L\left(\frac{T_1 - T_2}{T_1}\right)$$

To show how the volume of one pound of dry saturated steam may be calculated, let the engine operate between two temperatures which differ by only a very small amount. We may call these temperatures T and $T - \triangle T$. The indicator diagram is represented by Fig. R.

Since the process in Fig. R is assumed to be a Carnot cycle, and consequently reversible,

$$e = \frac{W}{Q'} = \frac{T_1 - T_2}{T_1} = \frac{T - (T - \triangle T)}{T} = \frac{\triangle T}{T}$$

$Q' = JL$

From Fig. R,

$W = a\,b\,c\,d = a\,f\,b\,e - a\,f\,d + b\,e\,c = \triangle P\,(V - w) - a\,f\,d + b\,e\,c$

Suppose $e\,c$ greater than $f\,d$, then $e\,b\,c$ is less than $\triangle P(ec)$ and $f\,d\,a$ is less than $\triangle P(ec)$.

Subtracting these inequalities,

$$e\,b\,c - f\,d\,a < \triangle P\,(ec)$$
$$\therefore W = \triangle P\,(V - w)$$

with error less than $\triangle P\,(ec)$

But,

$$W = eQ' = \frac{\triangle T}{T} JL$$

Substituting,

$$\triangle P\,(V - w) = \frac{\triangle T}{T} JL \text{ with error less than } \triangle P(ec).$$

Divide by $\triangle P$.

$$V - w = \frac{JL}{T} \frac{\triangle T}{\triangle P} \text{ with error less than } (ec).$$

Let $\triangle P$ approach zero as a limit, then,

$$V - W = \frac{JL}{T} \frac{dT}{dP}$$

$\frac{dT}{dP}$ is the rate at which the temperature of saturated steam alters relatively to the pressure when the temperature is T. Thus, $V - w = \frac{JL}{T} \frac{dT}{dP}$ is a means of calculating the volume of one pound of steam when the values of L and of $\frac{dT}{dP}$ are known.

Reanault's experiments have determined L, and by giving the relation of P to T, they have also given data from which it is easy to find $\frac{dT}{dP}$ either by measuring the slope of the tangent to the curve of P and T or by differentiating a formula such as

$$\log P = 6.1007 - \frac{2732}{T} - \frac{396945}{T},$$

which expresses the experimental relation between these two quantities. It is in this way that values of V in steam tables have been determined, and the advantage of the method is that L and $\frac{dT}{dP}$ can be measured more accurately than V could itself be measured, and thus the values of V obtained indirectly from them are more likely to be right than those obtained by direct experiment.

The formula shows that the numbers found in this way depend on J and are nearly proportional to it, since w is small.

XXXI. To show that $\frac{Q}{T}$ for any two isothermals between the same two adiabatics is the same, let Fig. S plot the process of two isothermals between the two adiabatic curves as shown, and let T_1 represent the absolute temperature at the beginning of the cycle at a and along the isothermal $a - b$. Let T_2 represent the absolute temperature along the second isothermal $c - d$, both isothermals being intercepted by the

FIG. S.

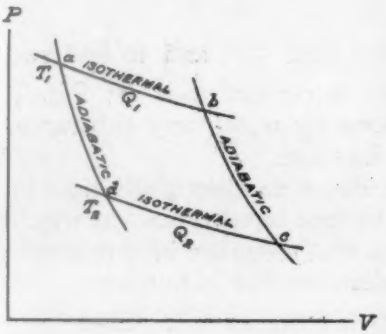
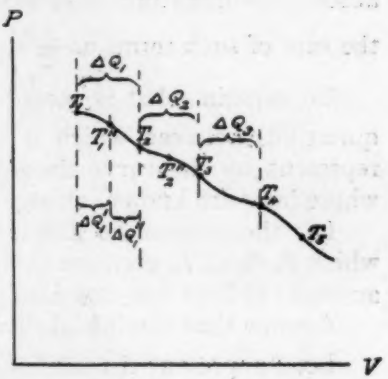


FIG. T.



adiabatics $a - d$ and $b - c$. In passing from a to b the substance takes in heat during the operation $= Q_1$. In passing from c to d heat is rejected to the amount Q_2, or *vice versa* taken in from d to c.

In the adiabatics $b - c$ and $d - a$ heat is neither taken in nor rejected. The efficiency of the process is the ratio:

$$\frac{\text{Heat converted into work}}{\text{Heat supplied}} = \frac{Q'' - Q'}{Q''} = \frac{T_1 - T_2}{T_1}$$

But

$$Q'' = Q_1 \text{ and } Q' = Q_2$$

$$\therefore \frac{Q_1 - Q_2}{Q_1} = \frac{T_1 - T_2}{T_1}$$

$$1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$

$$\therefore \frac{Q_2}{Q_1} = \frac{T_2}{T_1}$$

or

$$\frac{Q_2}{T_2} = \frac{Q_1}{T_1}$$

Hence $\frac{Q}{T}$ for any two isothermals between the same two adiabatics is the same.

XXXII. When a substance takes in or rejects heat in passing from one state to another, it may be considered to perform a process made up of the addition or rejection of heat in quantities bearing some relation to the absolute temperatures at which heat is taken in or rejected.

A summation of these amounts of heat at their respective absolute temperatures may be written: limit $\Sigma \frac{\Delta Q}{T}$ (*i.e.*, limit of the sum of such terms as $\frac{\Delta Q}{T}$).

To explain what is meant by limit $\frac{\Delta Q}{T}$, and to find two quantities between which it lies in certain cases, let Fig. T represent by the curve the process by which any substance, whose laws are known, changes its state.

Let the process be divided into a number of divisions in which T_1, T_2, T_3, T_4, etc., are the absolute temperatures at which amounts of heat ΔQ_1, ΔQ_2, ΔQ_3, ΔQ_4, etc., are taken in or rejected.

Assume that the initial divisions are five in number.

Let S represent the sum of such terms as $\frac{\Delta Q}{T}$. Then

$$S' = \frac{\Delta Q_1}{T_1} + \frac{\Delta Q_2}{T_2} + \frac{\Delta Q_3}{T_3} + \text{etc.} = \Sigma_5 \frac{\Delta Q}{T}$$

Divide each division in the process into two parts. Then

$$S'' = \frac{\Delta Q_1'}{T_1} + \frac{\Delta Q_1''}{T''} + \frac{\Delta Q_2'}{T_2} + \frac{\Delta Q_1''}{T_2''} + \text{etc.} = \Sigma_{10} \frac{\Delta Q}{T}$$

Again divide each part into two. Then

$$S''' = \Sigma_{20} \frac{\Delta Q}{T}$$

$$\Delta Q_1 = \Delta Q_1' + \Delta Q_1''$$

But $\frac{\Delta Q_1' + \Delta Q_1''}{T_1}$ is not equal to $\frac{\Delta Q_1'}{T_1} + \frac{\Delta Q_1''}{T_1''}$

By taking the divisions small enough the error can be made as small as we please, and by going to the limit:

$$S = \text{limit } \Sigma \frac{\Delta Q}{T} = \Sigma \frac{dQ}{T}$$

If in the diagram Fig. T we let the greatest temperature from the beginning of the process be T_G and the lowest T_L, the following inequalities result, when all the $\triangle Q$'s are positive:

$$\frac{\triangle Q_1}{T_G} \gtrless \frac{\triangle Q_1}{T_1} \gtrless \frac{\triangle Q_1}{T_L}$$
$$\frac{\triangle Q_2}{T_G} \gtrless \frac{\triangle Q_2}{T_2} \gtrless \frac{\triangle Q_2}{T_L}$$

and so on for any number of terms.

Adding these inequalities:

$$\frac{1}{T_G}(\triangle Q_1 + \triangle Q_2 + \triangle Q_3 + \text{etc.}) \gtrless \Sigma \frac{\triangle Q}{T} \gtrless \frac{1}{T_L}(\triangle Q + \triangle Q + \triangle Q + \text{etc.})$$

$$\therefore \frac{Q}{T_G} \gtrless \Sigma \frac{\triangle Q}{T} \gtrless \frac{Q}{T_L}$$

Increasing the number of divisions indefinitely:

$$\frac{Q}{T_G} \gtrless \text{limit } \Sigma \frac{\triangle Q}{T} \gtrless \frac{Q}{T_L}$$

For isothermal expansion or compression:

$$T_L = T = T_G$$

$$\therefore \frac{Q}{T} \gtrless \text{limit } \Sigma \frac{\triangle Q}{T} \gtrless \frac{Q}{T}$$

$$\therefore \text{limit } \Sigma \frac{\triangle Q}{T} = \frac{Q}{T} \text{ for isothermal.}$$

In adiabatic expansion or compression:

$$Q = 0$$

$$\therefore 0 \gtrless \text{limit } \Sigma \frac{\triangle Q}{T} \gtrless 0$$

$$\therefore \text{limit } \Sigma \frac{\triangle Q}{T} = 0 \text{ for adiabatic expansion or compression.}$$

XXXIII. Proof that the limit $\Sigma \frac{\triangle Q}{T}$ is the same for any two processes between the same two states:

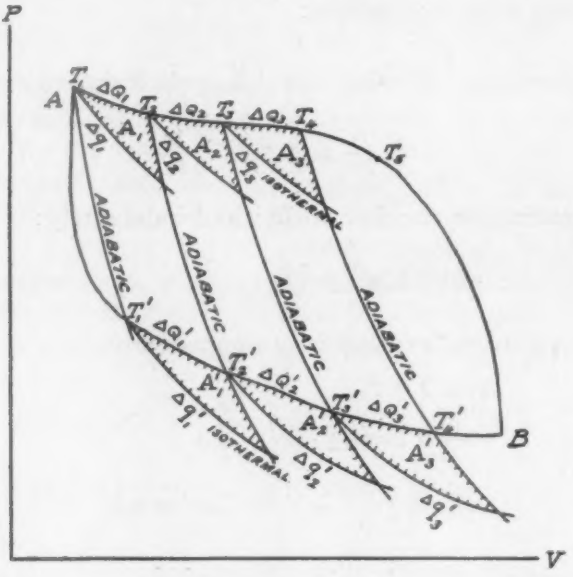
Let Fig. U represent a pressure volume diagram for any substance with the two processes as shown between the two states A and B.

To prove

$$\left(\begin{array}{c}\text{limit } \Sigma \frac{\Delta Q}{T} \\ \text{of} \\ \text{upper curve}\end{array}\right) - \left(\begin{array}{c}\text{limit } \Sigma \frac{\Delta Q}{T} \\ \text{of} \\ \text{lower curve}\end{array}\right)$$

Divide the upper curve into parts in which ΔQ_1, ΔQ_2, etc., will represent heat taken in or rejected at temperatures

FIG. U.



T_1, T_2, T_3, etc., and through these divisions pass adiabatic lines intersecting the lower curve as shown and dividing it at T'_1, T'_2, T'_3, etc., with heats $\Delta Q'_1$, $\Delta Q'_2$, $\Delta Q'_3$, etc., respectively.

Through T_1, T_2, T_3, etc., T'_1, T'_2, T'_3, etc., pass isothermals intersecting the adiabatics and curves A B as shown, and let Δq_1, Δq_2, etc., and $\Delta q'_1$, $\Delta q'_2$, etc., represent the heats taken in or rejected for these isothermals respectively, and let A_1, A_2, A_3, etc., A'_1,A'_2,A'_3, etc., represent the respective areas of the small triangles comprehended between the curves A B and the adiabatics and isothermals. Take any small triangular curve such as represented on an enlarged scale (Fig. V).

Since Fig. V is a closed curve, it represents a cyclic process:

Hence $W = Q$

But $Q = \Delta Q_3 + 0 - \Delta q_3$

$\therefore W = A_3 = \Delta Q_3 - \Delta q_3$

$\therefore \Delta Q_3 = A_3 + \Delta q_3$

Divide by T_3

$$\frac{\Delta Q_3}{T_3} = \frac{\Delta q_3}{T_3} + \frac{A_3}{T_3}$$

Similarly,

$$\frac{Q'_3}{T'_3} = \frac{q'_3}{T'_3} + \frac{A'_3}{T'_3}$$

Subtracting the latter from the former:

$$\frac{\Delta Q_3}{T_3} - \frac{\Delta Q'_3}{T'_3} = \frac{\Delta q_3}{T_3} - \frac{\Delta q'_3}{T'_3} + \frac{A_3}{T_3} - \frac{A'_3}{T'_3}$$

FIG. V.

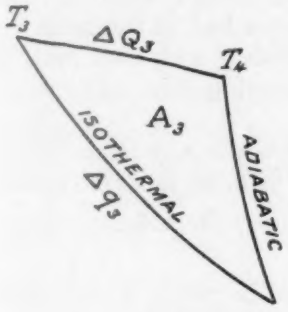
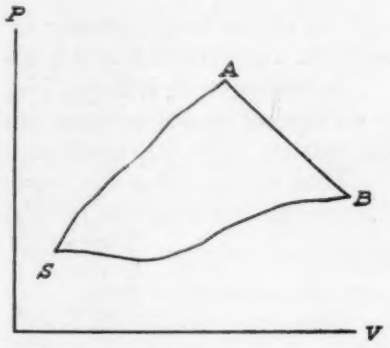


FIG. W.



But from XXXI,

$$\frac{\Delta q_3}{T_3} - \frac{\Delta q'_3}{T'_3} = 0$$

$$\therefore \frac{\Delta Q_3}{T_3} = \frac{\Delta Q'_3}{T'_3} + \frac{A_3}{T_3} - \frac{A'_3}{T'_3}$$

Performing the same process for each division and adding all together:

$$\begin{pmatrix} \Sigma \frac{\Delta Q}{T} \\ \text{upper} \\ \text{curve} \end{pmatrix} = \begin{pmatrix} \Sigma \frac{\Delta Q_1}{T} \\ \text{lower} \\ \text{curve} \end{pmatrix} + \begin{pmatrix} \Sigma \frac{A}{T} \\ \text{upper} \\ \text{curve} \end{pmatrix} - \begin{pmatrix} \Sigma \frac{A_1}{T} \\ \text{lower} \\ \text{curve} \end{pmatrix}$$

Taking an infinitely large number of divisions:

$$\begin{pmatrix} \text{limit } \Sigma \frac{\Delta Q}{T} \\ \text{of} \\ \text{upper curve} \end{pmatrix} - \begin{pmatrix} \text{limit } \Sigma \frac{\Delta Q}{T} \\ \text{of} \\ \text{lower curve} \end{pmatrix}$$

$\therefore$ the limit $\Sigma \frac{\Delta Q}{T}$ is the same for any two processes between the same two states.

XXXIV. When a substance takes in or rejects heat, it is said to change its entropy, the change of entropy being defined by the expression:

$$\text{limit } \Sigma \frac{\Delta Q}{T} \text{ or } \Sigma \frac{dQ}{T},$$

each dQ of the heat taken in or rejected being divided by the absolute temperature which the substance had at the time.

In dealing with entropy, just as in dealing with total heat, it is convenient to choose some arbitrary starting point and reckon the entropy from that point as a zero.

Thus in reckoning the entropy of steam at any temperature the condition of water at 32° Fahr. may be taken as a convenient datum and calculate $\Sigma \frac{dQ}{T}$ from that, calling the value so calculated the entropy of steam.

Entropy is usually denoted by ϕ, and in giving it numerical values it is to be calculated per unit mass of the substance considered.

From this definition and what has preceded, it is evident that when a substance is going through an adiabatic process its entropy does not change, since heat is neither added to nor taken from the substance. Also, in a cyclic process $\Sigma \frac{dQ}{T} = 0$ when the whole cycle is considered. Hence, when the cycle is completed the entropy of the substance, as well as its pressure, temperature, volume, and initial energy, was returned to the value which it had at the beginning of the cycle.

Just as isothermal lines are lines of uniform temperature, so adiabatic lines are lines of uniform entropy, and just as isothermals can be distinguished by numbers T_1, T_2, etc., denoting the particular temperature for which each is drawn, so adiabatics can be distinguished by numbers ϕ_1, ϕ_2, etc., denoting the particular value of the entropy of each. From this point of view adiabatics are often called isentropic lines.

In Fig. W let S represent the standard state of a substance, which for water is usually taken at 32° Fahr., as explained above.

Let any other state of the substance be represented by A and calculate:

limit $\Sigma \frac{\triangle Q}{T}$ for SA. Then the entropy of $A = \phi_A = \text{limit} \underset{SA}{\Sigma} \frac{\triangle Q}{T}$

Take any other state of the substance, such as B:

Then $\phi_B = \text{limit} \underset{SB}{\Sigma} \frac{\triangle Q}{T}$ = entropy of B.

But from XXXIII,

$$\phi_B = \text{limit} \underset{SB}{\Sigma} \frac{\triangle Q}{T} = \text{limit} \underset{SA}{\Sigma} \frac{\triangle Q}{T} + \text{limit} \underset{AB}{\Sigma} \frac{\triangle Q}{T} = \phi_A + \text{limit} \underset{AB}{\Sigma} \frac{\triangle Q}{T}$$

$$\therefore \phi_B - \phi_A = \text{limit} \underset{AB}{\Sigma} \frac{\triangle Q}{T}$$

Hence the difference in entropy between any two states of a substance is equal to the limit $\Sigma \frac{\triangle Q}{T}$ between these two states, irrespective of the process between the two states.

If in Fig. W the process between A and B is adiabatic, the limit $\underset{AB}{\Sigma} \frac{Q}{T}$ is zero, and hence in adiabatic expansion or compression $\phi_B = \phi_A$, or the entropy is constant.

XXXV. The change of state of a substance may be plotted on a diagram having absolute temperatures for ordinates and entropy for abscissæ, just as such processes are plotted on the pressure volume diagram. Such diagrams are called temperature-entropy diagrams, and are governed by the following principles:

First Principle.—To every point on the PV diagram there corresponds one, and only one, point on the ϕT diagram.

Second Principle.—To a cyclic process on the PV diagram there corresponds a closed curve on the ϕT diagram.

Third Principle.—To every point on the ϕT diagram there corresponds one, and only one, point on the PV diagram.

Fourth Principle.—An isothermal on the ϕT diagram is a horizontal line.

Fifth Principle.—An adiabatic on the ϕT diagram is a vertical line.

Sixth Principle.—On the ϕT diagram the heat supplied is represented in the same way as the work done is represented on the PV diagram, viz., by the area under the curve.

XXXVI. The efficiency of Carnot's cycle may be verified by means of the ϕT diagram as follows:

FIG. X.

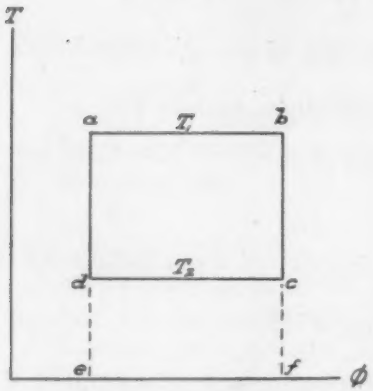
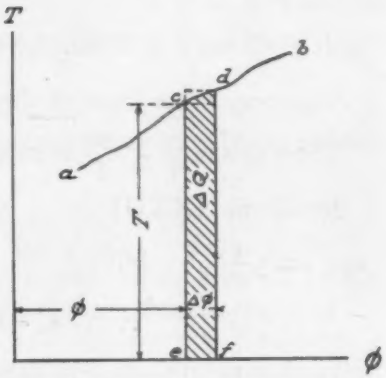


FIG. Y.



In Fig. X let $a\,b\,c\,d$ represent a Carnot cycle in which $a\,b$ is the isothermal expansion, $b\,c$ the adiabatic expansion, $c\,d$ the isothermal compression, and $d\,a$ the adiabatic compression.

The efficiency in any engine is the ratio of the heat converted into work to the heat supplied, or

$$e = \frac{Q'' - Q'}{Q''}.$$

From the figure,

$$Q'' = \text{area } a\,b\,f\,e\,a = T_1(\phi_b - \phi_a)$$
$$Q' = \text{area } d\,c\,f\,e\,d = T_2(\phi_b - \phi_a)$$

Subtracting and dividing by Q'' and its equivalent,

$$e = \frac{Q'' - Q'}{Q''} = \frac{T_1(\phi_b - \phi_a) - T_2(\phi_b - \phi_a)}{T_1(\phi_b - \phi_a)}$$
$$\therefore e = \frac{T_1 - T_2}{T_2},$$

which is the expression of the efficiency for a Carnot cycle.

XXXVII. Proof that the derivative of ϕ with respect to T is equal to $\frac{1}{T}$.

Let Fig. Y represent a ϕT diagram, plotting any process $a\,b$ as shown.

At any point on $a\,b$, such as c, the entropy will be ϕ and the temperature T.

At any other point adjacent to c on $a\,b$, such as d, the entropy will be $\phi + \Delta\phi$ and the temperature $T + \Delta T$.

From the figure,

$$e\,c = T$$
$$e\,f = \Delta\phi$$

Also ΔQ is equal to the area under the curve from c to d.

$$f\,d = T + \Delta T$$
$$\Delta Q < (T + \Delta T)\,\Delta\phi$$
$$\Delta Q > T(\Delta\phi)$$
$$\frac{\Delta\phi}{\Delta Q} > \frac{1}{T + \Delta T} \text{ and } \frac{\Delta\phi}{\Delta Q} < \frac{1}{T}$$

If the division cd is taken indefinitely small and ΔQ approaches zero as a limit,

$$\frac{d\phi}{dQ} \not< \frac{1}{T} \text{ and } \frac{d\phi}{dQ} \not> \frac{1}{T}$$
$$\therefore \frac{d\phi}{dQ} = \frac{1}{T}$$

Therefore the derivative of the entropy with respect to the temperature is equal to $\frac{1}{T}$.

XXXVIII. Deduction of the expression for the entropy of water at any temperature:

Let w = the state of water at 32° Fahr., called the standard state. Assume one pound of water raised 1° Fahr., then, $Q = ms\,(t - 32°) = t - 32°$, since $m = 1$ pound and $s = 1$.

But, $t = T - 461$.
$\therefore Q = T - 493$.

Taking the derivative of Q with respect to T—

$$\frac{dQ}{dT} = 1$$

But, $\frac{d\phi}{dQ} = \frac{1}{T}$

$$\frac{d\phi}{dT} = \left(\frac{d\phi}{dQ}\right)\left(\frac{dQ}{dT}\right) = \frac{1}{T}$$

$$\therefore \frac{d\phi}{dT} = \frac{1}{T} = \frac{d}{dT}(\log T) \text{ or}$$

$$\frac{d}{dT}(\phi - \log T) = 0$$

FIG. Z.

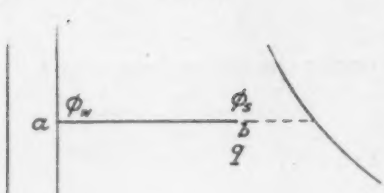
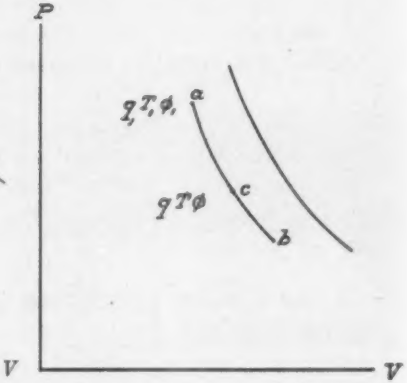


FIG. a.



If the derivative of a quantity is equal to zero, the quantity itself is equal to a constant.

$$\therefore \phi - \log T = K$$

When $T = 493$, $\phi = 0$ (since $493 = S$)

Substituting in the above—

$$K = -\log 493$$

Inserting this value of K—

$$\phi \text{ water} = \log T - \log 493 = \log \frac{T}{493},$$

which is the expression for entropy of water at any temperature.

XXXIX. Deduction of the expression for the entropy of wet steam of any dryness q and temperature T:

On the diagram Fig. Z let ϕ_w = entropy of water which is expanded isothermally from a to b, and let ϕ_s = entropy of the wet steam at b whose dryness is q.

From what has preceded—

$$\phi_s - \phi_w = \text{limit} \sum_{ab} \frac{Q}{T}$$

But ab is an isothermal,

$$\therefore \phi_s - \phi_w = \frac{Q}{T} = \frac{qL}{T}$$

$$\phi_s = \phi_w + \frac{qL}{T} = \log \frac{T}{493} + \frac{qL}{T}$$

$$\therefore \phi_s = \log \frac{T}{493} + \frac{qL}{T} = \phi_w + \frac{qL}{T},$$

which is the expression for the entropy of wet steam of any dryness q and temperature T.

If the steam be dry and saturated—

$$\phi_s = \log \frac{T}{493} + \frac{L}{T} = \phi_w + \frac{L}{T}$$

XL. Derivation of the adiabatic equation for wet steam:

Let Fig. a represent the PV diagram for the adiabatic expansion of wet steam plotted by the curve $a\,b$. Let the point a have dryness q_1, temperature T_1, and entropy ϕ_1.

Take any other point such as c on the curve $a\,b$ and let the dryness, temperature, and entropy be q, T, and ϕ respectively.

From XXXIX—

$$\phi_1 = \log \frac{T_1}{493} + \frac{q_1 L_1}{T_1}$$

$$\phi = \log \frac{T}{493} + \frac{qL}{T}$$

But $\phi_1 = \phi$, since the expansion is adiabatic.

$$\therefore \log \frac{T}{493} + \frac{qL}{T} = \log \frac{T_1}{493} + \frac{q_1 L_1}{T_1}$$

Transposing,

$$\frac{qL}{T} = \log \frac{T_1}{493} - \log \frac{T}{493} + \frac{q_1 L_1}{T_1}$$

$$\therefore q = \frac{T}{L}\left(\log \frac{T_1}{T} + \frac{q_1 L_1}{T_1}\right)$$

or

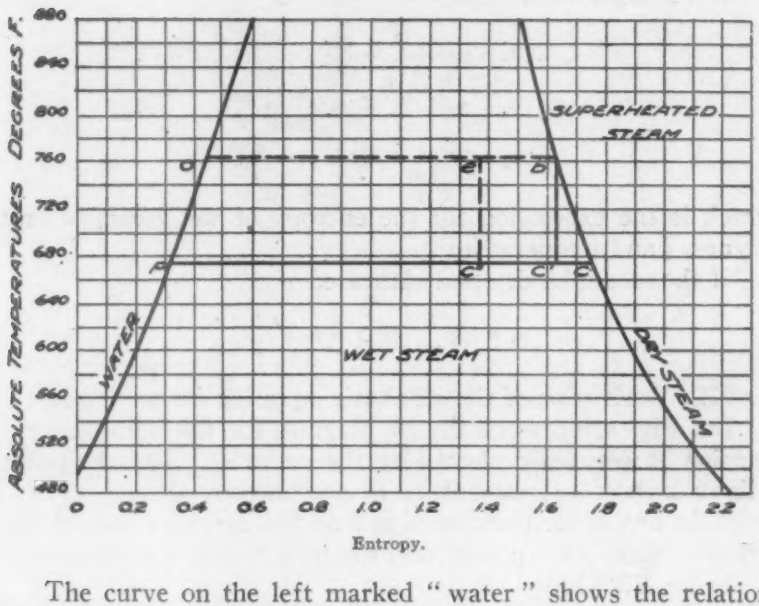
$$q = \frac{T}{L}\left(\frac{q_1 L_1}{T_1} + \log \frac{T_1}{T}\right)$$

which is the equation for the adiabatic expansion of wet stean .

XLI. In applying the entropy-temperature diagram to the investigation of particular cases in the expansion of steam, a chart

showing the values of the entropy of water and steam is convenient as a reference. Such a chart is shown in Fig. *b*.

FIG. *b*.



The curve on the left marked "water" shows the relation of entropy to temperature before steam begins to form, while the curve on the right marked "steam" shows the same relation when all the water is converted into steam.

The horizontal distance between the two curves at any point, or $\phi_s - \phi_w$, represents the gain of entropy which occurs while the water is changing into steam, or $\frac{L}{T}$. An extension of the diagram to the left might be drawn in the form of a horizontal line at 32° F. to show the change of entropy when ice melts.

The values of the entropy on the diagram relate to 1 pound of water or steam reckoned from water at 32° Fahr.

From this diagram, together with the knowledge of the relation of pressure to volume in saturated steam, furnished by steam tables, it is easy to determine what proportion of water will be present at any state in adiabatic expansion or compression, and hence to draw the ordinary indicator diagram or pressure volume curve for an adiabatic process.

(To be continued)

NOTES FROM THE U. S. BUREAU OF STANDARDS.[1]

THE DETERMINATION OF PHOSPHORUS IN STEELS CONTAINING VANADIUM.[2]

By J. R. Cain and F. H. Tucker.

In order to precipitate phosphorus quantitatively as phosphomolybdate from steels containing vanadium, it is necessary to reduce the latter to the quadrivalent state, otherwise precipitation is incomplete and there is contamination of the phosphomolybdate by vanadium. In the present method ferrous sulphate in slight excess is used as the reducing agent, and the following conditions should be observed:

(1) The temperature of precipitation should be held at a point (15° to 20°) where the nitric acid does not oxidize the excess of ferrous salt or the reduced vanadium before complete precipitation of phosphorus takes place; (2) the partial neutralization with ammonia, frequently used when phosphorus is precipitated as phosphomolybdate, must be made before reduction of the vanadic acid, otherwise the heat of neutralization causes the oxidation of most of the ferrous iron and reduced vanadium by the nitric acid; (3) care must be taken to prevent the action of oxides of nitrogen, formed by interaction of ferrous salt and nitric acid, on the reduced vanadium, since these substances seem to catalyze the oxidation of the vanadyl salt and may in some cases completely prevent precipitation of phosphorus, owing to the large amount of vanadic acid produced; (4) efficient means for shaking or agitation of the solutions in which precipitation is to take place must be provided.

The Bureau of Standards has prepared for early issue a circular concerning metallography in its wider sense. This is not restricted to the microscopical analysis alone. Thermal analysis, together with the correlation of physical properties with microscopical structure, thus find their place here.

The different methods of thermal analysis are briefly re-

[1] Communicated by the Bureau.

[2] Abstract of technologic paper.

viewed and compared. The importance that is attached to the metallographic method in the iron and steel industry is illustrated by a partial list of the more common applications in that field.

The tests that the Bureau of Standards is equipped at present for carrying out are:

1. Thermal: Cooling and heating curves, melting points, heat treatment of alloys as specified.

2. Microscopical: Preparation of specimens and photomicrographs of specified magnification up to 1000 diameter (higher magnification by special arrangement), microscopical examination after special heat treatment.

3. Miscellaneous: Examination of metals after failure for evidence of the cause of failure, determination of various physical constants of metals and their temperature coefficients.

DEHYDRATION OF CLAYS.

A TECHNOLOGIC paper entitled "Dehydration of Clays," by G. H. Brown and E. T. Montgomery, of the Bureau, is ready for publication. The paper gives a review and statement of the results of experimental work upon the dehydration of clay. Among the main conclusions are the following:

All of the combined water of clay is not part of the clay base in the sense of water of hydration. For this reason clay cannot be said to possess a definite dehydration temperature. The combined water is expelled at comparatively low temperatures, so that even at 450° C. the bulk of it may be driven off. In heating clay to constancy in weight at different temperatures the velocity of the reaction is very slow at first and becomes suddenly rapid at 500°. The remaining portion of the water is removed more slowly and difficultly, so that a temperature of not less than 800 ° is required to accomplish complete expulsion.

The distinctness of the endothermal lag as well as the total loss in weight upon ignition (excluding abnormal loss due to carbon, sulphur, etc.) is a criterion of the purity of a clay. Likewise the thermal acceleration at about 850° is shown more clearly by the higher types of clay.

It has been shown that the clay substance of the impure clays represents a type essentially different from that of the purer materials, contrary to the generally-accepted view. A

well-defined minimum is shown in the specific gravity curve of clays, located at approximately 500°.

Dehydration does not necessarily destroy the plasticity of clays, and hence the combined water appears to have no direct connection with the phenomenon of plasticity. Shales are least affected by heating within the dehydration temperature range, and, in fact, seem to be improved in plastic working behavior after preheating to about 500°. The surface clays examined lose their plasticity at the lowest temperatures, about 400°, followed by ball clay at 450°, kaolin 500°–600°, No. 2 fire clays 600°–750°, and shales 750°–800°.

It was likewise shown that the presence of organic compounds cannot be a primary cause of plasticity, since these are oxidized in an atmosphere of pure air at about 500°. It was shown quite clearly that drying shrinkage is not a true criterion of plasticity, contrary to the statement of Rohland, who makes the claim that this contraction is the best measure of the property in question.

Cupola Furnace for Melting Iron. R. MOLDENKE. (*Trans. Amer. Inst. Min. Eng.*, 1913, 37.)—In practice the best results are obtained by the use of 300,000 cubic feet of air per hour for a cupola of 54 inches diameter. If the metal is introduced less than eight minutes after the commencement of blowing, the bed is too thin, and should be increased by charging a little more fuel between the metal charges, whilst if it be not introduced until after more than ten minutes the bed is too thick and should be correspondingly reduced. The following conditions should be observed: (1) The proper amount of air required by the capacity of the cupola should be used; (2) the bed coke should be dry and well lighted before charging; (3) the bed should be of the proper height to give "first iron" in from eight to ten minutes; (4) the metal charges should be of equal weight and no larger than will be just covered by the coke required to melt them; (5) the coke charges should be so adjusted to the metal charges that the melting zone remains stationary and at the right point; (6) the blast volume (not pressure) should be constant throughout the heat; (7) the charges should be evenly distributed; (8) only one row of tuyères should be used; (9) the melting rate should be watched and the intermediate coke charges adjusted accordingly; (10) large pieces of metal should be avoided; (11) heavy coke with small percentages of cell space can stand large charges, while light coke with a large percentage of cell space must have very small charges to yield the best results.

Influence of Sulphur on Cast Iron. H. I. COE. (*Proc. Brit. Foundrymen's Assoc.*, 1911–1912, 78.)—A series of test bars was prepared from pure materials and was examined chemically, physically, and metallographically. The results show that: (*a*) With low silicon content a small amount of sulphur causes nearly all the carbon to become combined. With high silicon content the effect of sulphur in this respect is much less marked. (*b*) There appears to be a critical point, which varies with the silicon content, at which the effect of sulphur changes suddenly. (*c*) The addition of sulphur increases tenacity, transverse strength, and hardness. This influence is due partly to its effect on the condition of the carbon, partly to its modifying the dendritic character of the silicious irons. (*d*) Manganese neutralizes the influence of sulphur on the condition of the carbon, and, if in excess, eliminates sulphur by separation as manganese sulphide. Sulphur is most dangerous in irons low in silicon and manganese. These results were obtained in the absence of phosphorus, and probably would be modified in the case of commercial pig iron. Cast iron is desulphurized either by the addition of ferromanganese or by Saniter's process, which consists in mixing burnt lime and calcium chloride with the molten charge, thus producing calcium sulphide. For malleable cast iron, if the Réaumur process is employed, 0.2 to 0.4 per cent. of sulphur may be present, but for "Blackheart" castings 0.05 per cent. is the maximum permissible, since in the Réaumur process the annealing is oxidizing, and the stability of the carbide as regards decomposition into iron and graphite is of little importance, while the production of "Blackheart" castings depends essentially on the decomposition of iron carbide. As sulphur prevents this decomposition, it is therefore harmful.

Chemical Nature of Radioactive Elements. ALEX FLECK. (*Eng.*, xciv, No. 2443, p. 582.)—Mr. Fleck reaches the same conclusion as Marckwald and Keetman, that thorium and uranium X could not be separated. Trying all possible chemical methods, and relying chiefly on fractional precipitation finally, he stated that he had failed to change the concentration of the short-lived radio-elements in thorium. Similarly, he had found radio-actinium and thorium, and thorium B and lead, to represent two pairs of chemically inseparable elements.

Comparison between Rattler Test and Sand-blast Test for Paving Bricks. E. ORTON, JR. (*Trans. Amer. Ceramic Soc.*, xiv, 180.)—On either technical or economic grounds the sand-blast method is found to have no advantage over the rattler process as a method of testing paving bricks for resistance and wear. It measures hardness rather than strength or toughness, and, as a laboratory process, is recommended for exposing the structure of strong bodies, whether natural or artificial.

THE FRANKLIN INSTITUTE

(Proceedings of the Stated Meeting held Wednesday, April 16, 1913.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 16, 1913.

VICE-PRESIDENT COLEMAN SELLERS *in the Chair.*

Additions to membership, 36.

After the transaction of the usual Institute business a joint meeting was held with the Philadelphia Section of the American Institute of Electrical Engineers, Vice-President Sellers and Chairman Hornor presiding jointly.

Vice-President Sellers introduced Dr. G. W. Pierce, Assistant Professor of Physics, Harvard University, who spoke on "The Wireless Telephone."

Dr. Pierce first reviewed the methods of producing high-frequency electric oscillations by the singing-arc, the quenched-spark and the high-frequency generator, illustrating his remarks by lantern slides and by demonstrations of the first and second of these methods.

By means of schematic diagrams, he explained how such oscillations produced the continuous train of magnetic waves necessary for wireless telephony.

He stated that the chief advantage of wireless telephony over telegraphy was that less trouble was experienced from atmospheric and other interferences, since words could be interpreted more easily than signals, even if only a few syllables of such words were audible.

Dr. Pierce stated that wireless telephony had already been successful over a distance of 35 miles.

After a vote of thanks to the speaker, the meeting adjourned.

R. B. OWENS,
Secretary.

THE FRANKLIN INSTITUTE SCHOOL OF MECHANIC ARTS—REPORT OF THE DIRECTOR FOR THE SEASON 1912–1913.

(Abstract.)

To all who have the interests of the School at heart, it is a matter of gratification to note that the steady increase in the enrollment, which began with the reorganization of the work in all Departments in 1910, still persists.

In the season 1909–10, 201 students were registered in the School. This had been an average figure for a number of years. The enrollment increased to 232 in the following season. Last year 292 students were reported on the register, and now, during the sessions just completed, 305 students have been in attendance.

Although this latter figure is sufficient to evidence not only the long-continued (the School has just completed its eighty-ninth year) but also the still increasing prosperity of the School, it might here be stated that it represents only the number of individual names on the roll, and therefore takes no special account of the number of students which registered in more than one course. The majority of students attended, as usual, either the Drawing or Naval Architecture classes on Tuesday and Thursday evenings or the Mathematics or Mechanics classes on Mondays and Wednesdays; the register shows, however, that sixteen students attended the School for all four evenings weekly.

Certificates for the satisfactory completion of a two-year course in one of the four departments of Drawing, Mathematics, Mechanics or Naval Architecture are this year awarded to 45 students—an increase of six over last season. As in other years, a large proportion of these certificates goes to students in the Department of Drawing—Mechanical, Architectural or Freehand and Water Color classes—although this season there is a notable increase in the number of graduates in the Department of Mechanics.

The two-year courses offered in both Mathematics and Mechanics embrace several separate subjects, to each of which one term of three months is allotted. This arrangement permits of a number of combinations of subjects to form a complete course for a particular student, but at the same time also lessens the number of possible graduates in these Departments, as so many students follow only partial courses in each.

At the close of the Winter Term seven students in the Department of Drawing were awarded Bartol Scholarships, entitling them to free tuition for the Spring Term, and now seven students are awarded scholarships covering their tuition for the first term of the coming season.

The New York Shipbuilding Company's Prize of a valuable set of drawing instruments is now awarded to the student of greatest merit in the Department of Naval Architecture.

Certificates of Honorable Mention are also now awarded to those students in the respective classes in all Departments who have shown the best attendance and have been most proficient in their work.

The list of graduates for the season 1912–13 is appended.

I desire to express my sincere appreciation of the continued co-operation of my associates in the faculty: Messrs. Wm. E. Bullock, H. C. Towle, Clement Remington, H. P. Tyson, I. P. Pedrick, R. R. Umstead, W. W. Twining, and F. H. Lobb, and of the work of Messrs. Charles Rommel and E. Bark, appointed on the staff this year.

WM. H. THORNE,
Director of the School.

PHILADELPHIA, April 18, 1913.

LIST OF GRADUATES, 1912–13.

MECHANICAL DRAWING.

Frederick J. Benz
Charles F. Carman
Edward C. W. Craven
Otto E. Dannenberg
T. J. Norman Derby
Robert N. Hudson
Herbert Jayes
Charles A. Johnson
James R. Leacock
Thomas Morrissey
George P. Read
William L. Shuster
Peter Siebold
William J. Wear, Jr.
John Weber

ARCHITECTURAL DRAWING.

Milton S. Dilworth
Harry Feldman
Albert J. Godfrey
Harry T. Godfrey
Michael Greenberg
William Saidel
Frederick H. Stigale
James T. Strahan
Walter T. Teichman

FREEHAND DRAWING AND WATER COLOR.

Sophie Colles
Raymond Murphy

MATHEMATICS.

William J. Hare
Aloysius Hinski
Julius M. Netzer
Otto Roeder
John A. Schneider
August G. Schweizer
T. L. Shannon
Richard M. Warren, Jr.
Louis G. Zelson

MECHANICS.

Robert T. Aiman
Clarence E. Bullinger
Eaton Burrows
Karl Fichtner
Stanley B. Furstenau
Frank H. Sauer
Wm. F. Stevenson

NAVAL ARCHITECTURE.

H. Y. Bradley
Maury P. Gregg
James G. Morgan

COMMITTEE ON SCIENCE AND THE ARTS.

(Abstract of Proceedings of the Stated Meeting held Wednesday, April 2, 1913.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 2, 1913.

MR. J. A. P. CRISFIELD *in the Chair.*

The following report was presented for final action:

No. 2529.—The work of Albert Sauveur in connection with the Metallography of Iron and Steel. Cresson Medal. Adopted.

The following reports were presented for first reading:

No. 2526.—C. Francis Jenkins's Motion Picture Apparatus.

No. 2531.—Barr's All-Glass Fruit and Preserve Jar.

R. B. OWENS,
Secretary.

SECTIONS.

Electrical Section.—A joint meeting of the section and of the Philadelphia Section of the American Institute of Electrical Engineers was held in the Hall of the Institute on Thursday evening, April 3, 1913, at 8 o'clock.

Dr. George A. Hoadley and Mr. H. A. Hornor presided jointly.

Mr. Hornor presented a communication on "The Electrical Equipment of the Modern Battleship."

The speaker emphasized the lead taken by questions of power distribution in modern ships, with its consequent effect upon the kind of installation advisable. He outlined the uses of electricity for the operation of the various auxiliaries, including pumps, fans, heaters, steering gear, signalling, etc.

Some remarks were also directed to the problem of propulsion by means of electric coupling.

Mr. Hornor's paper was illustrated by lantern slides.

After a brief discussion, the thanks of the meeting were extended to the speaker.

Adjourned.

WILLIAM E. BULLOCK,
Acting Secretary.

Section of Physics and Chemistry.—A meeting of the section was held on Thursday evening, April 10, 1913, in the Hall of the Institute, at 8 o'clock.

Dr. Harry F. Keller in the Chair.

The Chairman called on Dr. Robert H. Bradbury, head of the Department of Science, Southern High and Manual Training School, Philadelphia, member of the Institute, and president of the section, who gave an interesting and instructive lecture on "Colloids and Crystals: The Two Worlds of Matter."

Opening with definitions of the two classes of substances, the speaker continued with illustrations of colloidal solutions and the methods of obtaining and examining them, confining his remarks chiefly to non-reversible colloids. He also discussed the Brownian movement.

At the close of his remarks he prepared hydrosols of gold and silver, and of antimony sulphide, silver bromide, ferric oxide, etc. He also demonstrated the Tyndall effect for examining these sols.

After a brief discussion by members present, a vote of thanks was accorded the speaker and the meeting adjourned.

WILLIAM E. BULLOCK,
Acting Secretary.

MEMBERSHIP NOTES.

Elections to Membership.

(Stated Meeting of the Board of Managers, April 9, 1913.)

NON-RESIDENT LIFE.

MR. J. KEARSLEY M. HARRISON, The Tudor, Beacon and Joy Streets, Boston, Mass.

MR. SAMUEL INSULL, President, Commonwealth Edison Company, 120 West Adams Street, Chicago, Ill.

RESIDENT.

MR. CHAS. M. BALLANTINE, 4810 Germantown Avenue, Germantown, Philadelphia, Pa.

MR. SAMUEL B. BOWEN, North Penn Junction, Philadelphia, Pa.

MR. JOHN F. CONAWAY, National Umbrella Frame Company, Thirtieth and Thompson Streets, Philadelphia, Pa.

MR. CHARLES T. COWPERTHWAIT, 212 South Fourth Street, Philadelphia, Pa.

MR. WM. J. DAVIS, McHatton Foundry Company, Fifteenth Street and Washington Avenue, Philadelphia, Pa.

MR. SAMUEL BALTZ ECKERT, Devon, Chester County, Pa.

MR. N. E. FUNK, 5113 Kingsessing Avenue, Philadelphia, Pa.

MR. W. GRIFFIN GRIBBEL, 1513 Race Street, Philadelphia, Pa.

MR. J. C. HERSHEY, 1014 Market Street, Philadelphia, Pa.

MR. E. E. PENNOCK, 403 Bourse Building, Philadelphia, Pa.

MR. G. A. PIERCE, Wm. Cramp & Sons Ship and Engine Building Company, Philadelphia, Pa.

MR. MARSHALL R. PUGH, 601 Witherspoon Building, Philadelphia, Pa.

MR. PAUL SPENCER, northwest corner Broad and Arch Streets, Philadelphia, Pa.

PROF. W. E. S. TEMPLE, Department of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa.

MR. JOHN CASTLE WRIGHT, McHatton Foundry Company, Fifteenth Street and Washington Avenue, Philadelphia, Pa.

NON-RESIDENT.

MR. W. S. ANDREWS, Research Department, General Electric Company, Schenectady, N. Y.

DR. DONALD S. ASHBROOK, 2404 Willard Street, Wilmington, Del.

MR. FRANK L. CONNABLE, 622 Du Pont Building, Wilmington, Del.

MR. THOMAS A. EDISON, Orange, N. J.

MR. JAMES GAYLEY, 71 Broadway, New York City, N. Y.

DR. WM. PAUL GERHARD, Forty-second Street Building, New York City.

MR. W. HERMAN GREUL, 11th Avenue and Twenty-sixth Street, New York City, N. Y.

MR. ALLEN HAZEN, Forty-second Street Building, New York City, N. Y.

DR. EDWARD P. HYDE, 4503 Hough Avenue, N. E., Cleveland, Ohio.

DR. JOHN PRICE JACKSON, School of Engineering, The Pennsylvania State College, State College, Pa.
MR. WALDEMAR KAEMPFFERT, *Scientific American*, 361 Broadway, New York City, N. Y.
DR. JOHN F. KELLY, Pittsfield, Mass.
MR. H. WARD LEONARD, Lawrence Park, Bronxville, N. Y.
MR. OTTO LUYTIES, 546 Fifth Avenue, New York City, N. Y.
DR. ALFRED NOBLE, 7 East Forty-second Street, New York City, N. Y.
MR. MATHIAS PFATISCHER, 314 East Third Avenue, Roselle, N. J.
MR. FRANK J. SPRAGUE, 165 Broadway, New York City, N. Y.
PROF. CARL C. THOMAS, College of Mechanics and Engineering, The University of Wisconsin, Madison, Wis.
DR. MAXIMILIAN TOCH, 320 Fifth Avenue, New York City, N. Y.

Changes of Address.

MR. WALTER ATLEE, 410 Exchange Building, Los Angeles, Cal.
MR. EDWIN M. CHANCE, 61 South Pennsylvania Avenue, Wilkes-Barre, Pa.
MR. CHARLES DAY, 611 Chestnut Street, Philadelphia, Pa.
MR. EDWARD V. D'INVILLIERS, 518 Walnut Street, Philadelphia, Pa.
MR. W. R. HUTTINGER, 19 West Ridgewood Avenue, Ridgewood, N. J.
CAPT. A. F. LUCAS, 429 West 117th Street, New York City.
MR. F. H. SHELTON, 1714 Delancey Street, Philadelphia, Pa.
MR. JOHN E. NETHERY, 3333 North Broad Street, Philadelphia, Pa.
MR. CHAS. W. MCMEEKIN, Nevada City, Cal.

NECROLOGY.

James McCrea, eighth president of the Pennsylvania Railroad Company, was born in Philadelphia in 1848. He entered the service of the company at the age of seventeen and rose from the ranks. By 1882 he had attained the position of general manager of the Pennsylvania lines west of Pittsburgh. He became first vice-president a few years later, and, in 1907, president of the Pennsylvania system, succeeding Mr. A. J. Cassatt, whose great work he took up and successfully completed. His death in March of this year occurred shortly after his resignation, which latter was brought about by a personal desire to relinquish his arduous duties after nearly a half century of service.

Mr. McCrea was a member of the Institute since 1907.

William H. Merrick, retired financier and a patron of art, died on April 15th, at his residence in Germantown, Philadelphia, at the age of 82 years. Mr. Merrick was educated in the public schools of Philadelphia and at the University of Pennsylvania. He was for some years Director of the Philadelphia Savings Fund Society. He was one of the founders of the

Academy of the Fine Arts and School of Industrial Arts and the Zoölogical Society. His membership in local organizations included the American Philosophical Society and The Franklin Institute, with which latter he became connected in 1904.

Mr. Merrick was the son of Samuel V. Merrick, first president of the Pennsylvania Railroad and president of The Franklin Institute from 1842 to 1854.

Friedrich W. C. Schniewind was born at Bochum, in Westphalia, in 1861. He studied chemistry at Berlin, Munich, and Heidelberg, receiving the degree of Ph.D. from the University of Heidelberg. After some experience as a blast-furnace chemist, he came to this country in 1890 and conducted analytical laboratories at Cleveland, Ohio, and Crystal Falls, Mich. Four years later he became connected with the Otto Coke and Chemical Company, organized to introduce by-product coke ovens into this country. The United Coke and Gas Company succeeded the original company, and Dr. Schniewind acted as consulting engineer, later becoming manager and vice-president.

He was the author of numerous papers on coal carbonization, coke production, ammonia, benzol enrichment, and other subjects in industrial chemistry.

Dr. Schniewind was elected to membership of The Franklin Institute in 1905.

Mr. Samuel H. Cramp, Philadelphia, Pa.

LIBRARY NOTES.

Purchases.

ALLMAND, A. J.—The Principles of Applied Electrochemistry. 1912.

American Railway Master Mechanics Association.—Locomotive Dictionary. [c1912.]

BOHLE, H.—Electrical Photometry and Illumination. 1912.

BUTLER, E.—Evolution of the Internal Combustion Engine. 1912.

CHURCH, I. P.—Mechanics of Internal Work. 1910.

GRAY, A.—Electrical Machine Design. 1913.

HESS, H. D.—Machine Design. 1912.

HIRSHFELD, C. F., and W. N. BARNARD.—Elements of Heat Power Engineering. 1913.

HOBART, H. A.—Design of Polyphase Generators and Motors. 1913.

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Wilmington Board of Park Commissioners, Report for 1912. Wilmington, 1912. (From the Commissioners.)

BOOK NOTICES.

THE TECHNICAL ANALYSIS OF BRASS AND THE NON-FERROUS METALS. By William Benham Price, Chief Chemist, Scovill Manufacturing Company, and Richard K. Meade, Director of Meade Testing Laboratories, Allentown, Pa. 267 pages; illustrated; 12mo. Edition 1. New York, John Wiley & Sons, 1911. Price, $2.

After critical examination of this "handy volume" from title page to index the writer does not hesitate to say that he finds it crammed with valuable information in concentrated form,—*i.e.*, boiled down to smallest bulk,—and nothing appears to have been lost in the operation.

It is crystallized knowledge and experience in a special field which will be found especially useful to the busy man who does not have time or opportunity, amidst other occupations, to keep himself posted on all the modern methods of rapid analyses of brass and other non-ferrous alloys.

The authors have confined themselves rigidly to the main theme, covering practically all known methods of analysis, and do not refer to the specific gravity or microstructure of alloys. While these are very important adjuncts, they are not strictly germane to the work in hand, and would, if included, unduly enlarge the volume.

Few persons realize the enormous expansion of consumption of non-ferrous metals in recent years. Some idea of the economic value of bearing metals alone may be gained from a brief statement on the first page of the Introduction, which is as follows: "In view of the increase in the amount of machinery and rolling stock it is safe to say that the value of the bearing metal now in use is considerably over fifty million dollars." Presumably the authors are referring to this country only.

A feature which has impressed the reviewer favorably is the proper balance which appears to have been observed in respect to the relative importance of various methods of analysis of the metals and alloys. Thus, the electrolytic method is given prominence, wherever it is available, as being the simplest and most rapid, and where the electrolytic process is not suitable a brief note (as in the case of magnesium) is given, viz., "None at present known."

In the case of aluminum it is shown that this metal may be electrolytically separated as aluminum hydroxide, filtered off, ignited, and weighed as Al_2O_3, but it is said "this method is seldom used in practical work."

Notwithstanding statements that have been made from time to time in foreign technical journals that processes have been devised whereby aluminum may be "electrolytically deposited in metallic form" on other metals, this is still a mere *ignis fatuus*. The most glaring fraud ever perpetrated of this nature was in the claim made, years ago, that the cast-iron plates forming the metal covering of the great tower of the City Hall in Philadelphia were heavily coated with aluminum electrolytically deposited, and that they would consequently retain, for all time, the original neutral gray color, matching the stone on which the tower rests. Many thousands of dollars were paid by the city for this work, and it will be necessary,

sooner or later, to paint the metal work in order to prevent further rusting from exposure of the iron to the elements.

A pleasing feature of this book is the evident care that has been taken to give due credit, in footnotes, to the authors of various methods, or modifications of methods, therein described.

The book is divided into three parts, covering 260 pages in all: Part I—*Introduction;* Chapter I, Engineering Alloys; Chapter II, Apparatus for Electro-chemical Analyses. Part II—*Determination of the Metals.* Aluminum, Antimony, Arsenic, Bismuth, Cadmium, Copper, Iron, Lead, Magnesium, Manganese, Nickel and Cobalt, Phosphorus, Silica, Sulphur, Tin, Zinc. Part III—*Applied Examples of Alloy Analysis.* Aluminum Alloy, Antimony and Arsenic Alloy, Antimony, Arsenic and Tin Alloy, Antimony and Tin Alloy. Antimony and Lead Alloy, Babbitt Metal, Fusible Metals, Solders, etc., Brass, Bronze, Phosphor Bronze, Manganese-Phosphor-Bronze, Germán Silver, Watch Nickel, and Nickel Alloys, Spelter, Refined Copper Analysis, Exact Electrolytic Assay of Refined Copper, Determination of Arsenic and Antimony in Copper. Table of factors for use in alloy analysis.

The illustrations are drawn in outline and are reduced to the simplest forms; the only criticism to be offered is that there might be more of them with advantage to the text.

Finally, there is an Index covering several pages.

A. E. OUTERBRIDGE, JR.

METHODS OF MEASURING ELECTRICAL RESISTANCE. Edwin F. Northrup, Ph.D. McGraw-Hill Book Company, 1912. Price, $4. 8vo, 390 pages, numerous illustrations and diagrams.

The modern tendency toward specialization, and the wisdom of specializing are both well illustrated by the publication of this normal-sized book, which is devoted exclusively to the measurement of only one of the numerous electrical quantities. Not only did there exist enough material on the measurement of electrical resistance to fill a book, but the author makes no claim that even this compilation is a complete collection of all the methods, although it is no doubt the most complete one published, and apparently the first book ever published which is limited to resistance measurements alone.

The author has hereby set a good example, which could well be followed by others, as the books which promise to be most useful to the workers in theoretical and applied sciences are those in which are compiled the scattered products of the brains of many, as distinguished from a book which originated entirely in one brain. A book which can be depended upon to contain a complete collection of all existing knowledge on any specific subject is one which no one dealing with that subject, even only occasionally, can afford to do without. It is hoped that the present author's good example will be followed by similar collections of methods of measuring the other electrical quantities.

There are probably few who would be better suited to prepare such a

book than this author, who combines the ability to deal with the higher mathematics involved with many years of experience in laboratory testing and in the designing and making of instruments to carry out methods of making electrical measurements. Some of the methods are claimed to be new, and others are the author's modifications of methods devised by others.

The general plan of the book is that of a treatise rather than that of a reference book, the mathematical evolutions of final formulas being given, in many cases, in considerable details, unnecessarily detailed for the user of the methods, but useful to the student, the teacher, and the mathematical physicist. It is, however, also available as a reference book, although in some cases one may have to search under various headings and chapters to find all the available methods for any particular case.

The grouping and classifications of the methods might be open to criticism and possible improvement, as it sometimes brings the same subject under widely differing groups, the method of measuring the resistance of electrolytes, for instance, falling partly in Chapter II and partly in Chapter XI, due to what seems to the reviewer to be a somewhat unfortunate classification or grouping. But, owing to the complicated nature of any system of classification of such methods, it is hardly fair to the author to find fault with his method unless one can offer a better one.

One of the features which enhances the value of the book is that in many cases the author has himself applied and studied the particular method described and is therefore able to supplement the description with actual experience.

Supplementary chapters are devoted to discussion of measurements in general, including the estimation of errors, to instruments and their choice for specific measurements, and in an appendix are given interesting tables and data of use in such measurements.

The method of numbering the sections with the chapter number as the hundreds, and the numbering of the figures with the corresponding section numbers, greatly facilitate references and can be highly recommended to other authors of similar books as being useful and practical; it seems to be new in this book. From a book-maker's standpoint the book is all that can be desired in clearness of type and illustrations, most of which latter are original and are made by the so-called "wax" process, with very clear and distinct lettering.

The book shows unusual care and conscientiousness in its editing, which is quite in accordance with the usual careful, earnest, and conscientious work of that author. It is not likely that it will be found to contain the errors of carelessness and in typography which are, alas! too common in less carefully prepared books, and which tend to develop the thought that the same lack of attention and care was devoted to the matter itself.

The reviewer feels no hesitancy in recommending this book very highly to the teacher, the student, the worker in testing laboratories, and the practical electrical engineer, and he expresses the hope that it will be followed by further volumes giving compilations of the methods of measuring the other electrical quantities.

CARL HERING.

DIE ELEKTROLYTISCHE ALKALICHLORIDZERLEGUNG MIT STARREN METALLKATHODEN. By Dr. Jean Billiter. Published by Wilhelm Knapp, of Halle. 284 pages, 24.5 x 17 cm. Price, 16.50 marks.

This is part I of a comprehensive treatment of the subject of the electrolysis of the chlorides of potassium and sodium with solid metal cathodes. It forms No. 41 of Knapp's *Monographien über angewandte Elektrochemie*. Processes in which cathodes of mercury or of melted lead are employed are excluded, because they have already been treated in Lucion's monograph, which forms No. 23 of the same series.

With the exception of a brief but excellent introduction, the present volume is devoted to the patent literature of the subject. Four hundred and fifty German, English, and American patents are concisely and intelligibly discussed. Numerous diagrams add to the clearness of the text. The author has himself made important contributions to the subject, and some of the most successful processes described are his own.

Part II, which is ready for publication, will contain complete descriptions of the plants in which those processes which have found industrial application are carried out. The fact that a work which will probably approach 600 pages is necessary adequately to treat only one phase of the subject of the electrolysis of the alkali chlorides is impressive evidence of the activity of invention in the field. The book is an excellent one, which can be recommended without reserve to those interested in the subject. Since about 70,000 horsepower are devoted to sodium chloride electrolysis in the United States, it will probably be welcome to many American chemists. There is a list of the patents in order of number and a good alphabetical index.

ROBERT H. BRADBURY.

AN INTRODUCTION TO THE CHEMISTRY AND PHYSICS OF COLLOIDS. By E. Hatschek. Published by P. Blakiston, Philadelphia. 87 pages, 18.5 x 12 cm. Price, $1.

An excellent and timely little book. Although it offers a surprising amount of information in small space, it is readable and interesting. The author is fully familiar with the present condition of his subject, and the reviewer has noted no misstatements. The book is not overloaded with terminology, and the essential things that everyone wants to know are presented clearly and well.

ROBERT H. BRADBURY.

ALLEN'S COMMERCIAL ORGANIC ANALYSIS, vol. vii, 4th edition, edited by W. A. Davis and S. S. Sadtler, published by P. Blakiston. 563 pages, 23.5 x 14.5 cm. Price, $5.

The previous volumes of this indispensable treatise have been noticed. The present volume is devoted to Vegetable Alkaloids (Barger), Glucosides (Armstrong), Bitter Principles (Jones), Animal Bases (Taylor), Ptomaines (Barger), Animal Acids (Mandel), Lactic Acid (Davis), Cyanogen and its Derivatives (Philipp). Although the familiar order of the third edition has been retained as far as possible, the whole book has

been rewritten and brought abreast of the present state of organic analysis. It may be well to call attention to the fact that most of the more important vegetable alkaloids have already been handled under various headings in vol. vi.

ROBERT H. BRADBURY.

PUBLICATIONS RECEIVED.

An Introduction to the Physics and Chemistry of Colloids, by Emil Hatschek. Reprinted from *The Chemical World.* Text-books of Chemical Research and Engineering, 94 pages, illustrations, 12mo. Philadelphia, P. Blakiston's Son & Co., 1913. Price, $1.

Allen's Commercial Organic Analysis, a treatise on the properties, modes of assaying, and proximate analytical examination of the various organic chemicals and products employed in the arts, manufactures, medicine, etc. Vol. 7. Vegetable alkaloids, glucosides, non-glucosidal bitter principles, animal bases, animal acids, lactic acid, cyanogen and its derivatives, by the editors and the following contributors: Frankland Armstrong, G. C. Jones, A. E. Taylor, G. Barger, J. A. Mandel, Herbert Philipp. Fourth edition, entirely rewritten. Edited by W. B. Davis, B.Sc., A.C.G.I., and Samuel S. Sadtler, S.B. 563 pages, illustrations, 8vo. Philadelphia, P. Blakiston's Son & Co., 1913. Price, $5.

Mechanical Drawing, a treatise on technical drawing as expressed through the medium of the graphic language, by Otho M. Graves, Assistant Professor of Graphics, Lafayette College. 138 pages, illustrations, 8vo. Easton, Pa., The Chemical Publishing Company, 1912. Price, $2.

U. S. Department of Agriculture, Forest Service, Henry S. Graves, Forester: Geographic Distribution of North American Trees. Part 1—Pines, by George B. Sudworth, Dendrologist. 36 maps, folio. Washington, U. S. Geological Survey, 1913.

Paving Brick: The Necessity of Uniform Quality. Tests for High-grade Paving Bricks, by J. W. Howard, C.E., E.M. 15 pages, illustrations, 8vo. New York, author, 1913.

North Carolina Geological and Economic Survey, Joseph Hyde Pratt, State Geologist: Economic Series No. 32, Public Roads are Public Necessities, by Joseph Hyde Pratt, State Geologist. 62 pages, 8vo. Raleigh, State Printers, 1913.

American Telephone and Telegraph Company, Annual Report of the Directors to the Stockholders for the year ending December 31, 1912. 47 pages, 8vo. New York, 1913.

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U. S. Department of Agriculture, Office of Public Roads: Bulletin No. 47, Descriptive Catalogue of the Road Models of the Office of Public Roads, prepared in the Office of Public Roads. 29 pages, illustrations, plates, 8vo. Washington, Government Printing Office, 1913.

U. S. Bureau of Mines: Bulletin 52, Ignition of Mine Gases by the Filaments of Incandescent Lamps, by H. H. Clark and L. C. Ilsley. 31 pages, illustrations, plates, 8vo. Bulletin 63, Sampling Coal Deliveries and Types of Government Specifications for the Purchase of Coal, by George S. Pope. 68 pages, illustrations, plates, 8vo. Technical Paper 31, Apparatus for the Exact Analysis of Flue Gas, by George A. Burrell and Frank M. Seibert. 12 pages, illustrations, 8vo. Washington, Government Printing Office, 1912, 1913.

Canada Department of Mines, Mines Branch: Bulletin No. 8, Investigation of the Peat Bogs and Industry of Canada, 1910–11, by A. Anrep. 61 pages, illustrations, plates, maps, 8vo. Ottawa, Government Printing Bureau, 1912.

Bulletin of the Efficiency Society, Inc.: Volume 2, January, February, March, 1913. 47 pages, illustrations, quarto. New York, Society, 1913.

Prime Movers. S. Z. DE FERRANTI. (*The James Watt Lecture, Greenock,* 1913.)—Mr. Ferranti states that he has devised a turbine which is quite free from mechanical troubles at the highest temperature, and with great and rapid variations of temperature. The blading is of mild steel, electrically welded throughout, and with a thin coating of pure sheet nickel electrically welded on to the surface. The steam is worked as a gas at high temperature throughout the turbine; it is superheated initially and after the first expansion, then re-superheated before it does work in the second stage of the turbine, and exhausted in a superheated condition through a regenerator to the condenser. A 5000-horsepower turbine of this kind, which has been running for some time, when tested at a load of two-thirds full power on 7 pounds of steam, gave results corresponding to a consumption of 0.625 pound of oil per shaft-horsepower, with the steam supplied by an oil-fired boiler superheater system of 85 per cent. efficiency. The results now obtained indicate that when run at full load under favorable conditions this turbine will take less than 6 pounds of steam per shaft-horsepower and that the system will have a thermal efficiency of over 24 per cent., corresponding to an oil consumption of about 0.55 pound of oil per shaft-horsepower.

Solubility of Metals and Alloys. (*Mon. Sci.*, xxv, 837.)—Certain metals and alloys prepared in the electric furnace, which sometimes resist the most energetic chemical action, are readily attacked and completely dissolved when powdered and heated with an excess of phosphoric acid above 1.75 in density. This applies to metallic silicon, zirconium, tungsten, ferro titanium, vanadium, silico-manganese, titanium nitride, the alloy of ferrosilicon with 23 per cent. aluminum, boron-nickel, and carborundum. In all these reactions the carbon contained in the alloys remains, wholly or partially, in a flocculent condition in the syrupy liquid.

CURRENT TOPICS

The Chemical Constitution of the Kaolinite Molecule. J. W. MELLOR and A. D. HOLCROFT. (*Trans. Eng. Ceram. Soc.*, xi, 169.)—The heating curve and dehydration curve of well-defined crystals of kaolinite from the Glamorganshire coal field were determined. The thermal phenomena exhibited in the heating curve were similar to those of a china clay, a slight terrace in the curve being due to decrepitation and projection of the material from the crucible. The dehydration test confirmed the result previously obtained, that there is no definite temperature of dehydration. The total loss on ignition was 15.94 per cent., but the content of organic matter was large, and some other mineral, possibly halloysite or montmorillonite, was present to the extent of 10 to 15 per cent.

The Degree of Porosity of Paper. W. COLDITZ. (*Wochenbl. Papierfabr.*, xliv, 376.)—Printing papers require a harder or softer sizing according to the nature of the printing to be done and the consistence of the ink. It is not sufficiently recognized that the resistance or absorbency of paper toward oily printing inks has no direct connection with the hardness of sizing as usually measured in relation to aqueous writing inks. The resistance to oily inks depends on the closeness of texture and relative porosity of the paper. In default of a direct method of measuring the rate of penetration of oil varnishes through printing papers, the author adopts a method dependent on the fact that the porosity is expressed by the ratio of the apparent specific gravity of the paper to its real specific gravity. The apparent specific gravity is calculated by ascertaining the weight of a measured volume of the paper, whilst the real specific gravity of the solid constituents of the paper is calculated by ascertaining the amount of oil displaced by a given weight of the paper. For this purpose olive oil is employed, and it is essential to steep the paper in the oil for at least half a day to ensure the complete displacement of the air before the weighing is made. The procedure is the usual method of determining the specific gravity of solid bodies; a sinker large enough to contain the sample of paper is used, and its displacement of both oil and water has been previously determined.

Australian Radium. ANON. (*Sci. Amer.*, cvii, 26, 547.)—The *London Times* says the first sample of radium bromide produced outside of Europe has lately been manufactured in Sydney from Australian ores, and has a certified purity of 98.4 per cent. The plant is capable of producing 40 milligrammes weekly.

Production of Lead, Zinc, and Cadmium in 1911. ANON. (*Chem. Trade J.*, Dec. 14, 1912.)—*Lead.*—The annexed table shows the world's production of lead, in short tons, during the years 1909–11, inclusive:

Country.	1909.	1910.	1911.
Australia	85,098	108,907	109,789
Austria-Hungary	15,432	19,290	21,605
Belgium	44,423	44,864	33,951
Canada	22,928	16,535	11,795
France	29,652	22,266	25,353
Germany	185,076	176,258	177,801
Great Britain	31,085	32,628	29,872
Greece	16,865	18,519	15,763
Italy	24,361	15,983	18,408
Japan	3,748	3,858	3,858
Mexico	130,071	133,048	132,276
Russia	882	1,323	1,102
Spain	202,823	211,531	189,155
Sweden	220	441	2,866
Turkey in Asia	13,338	13,999	13,668
Other Countries	6,393	17,306	20,944
United States (domestic)	354,188	372,227	392,842
Total	1,166,583	1,208,983	1,201,048

Zinc.—The world's production of spelter in 1911 was again the largest in history, exceeding that of the record output of 1910 by 85,549 tons, or 9.6 per cent. The greatest increase was contributed by Germany, which exceeded its 1910 production by 24,962 tons. Belgium made a gain of 24,817 tons, and the United States 17,342 tons. The following totals, apportioned according to the country where smelted, and not according to the source of the ore, show the world's production, in short tons, during the years 1909–11, inclusive:

Country.	1909.	1910.	1911.
Australia		560	1,904
Austria and Italy	13,931	14,666	18,602
Belgium	184,194	190,233	215,050
France and Spain	61,859	65,191	70,791
Germany	242,594	251,046	276,008
Great Britain	65,422	69,531	73,803
Holland	21,548	23,121	25,059
Poland	8,758	9,514	10,952
United States	255,760	269,184	286,526
Totals	854,066	893,046	978,695

Cadmium.—The chief output of cadmium comes from the zinc-producing regions of Silesia, Germany, where it is recovered as a by-product in the distillation of zinc. Recently, in the United Kingdom, a little cadmium has been recovered in the purification of zinc sulphate in the manufacture of lithopone. The German production of cadmium during 1911 totalled 93,961 pounds, valued at $53,375, against 90,516 pounds, valued at $39,315, in 1910.

Mantles for Incandescent Gas Lighting. C. R. BÖHM. (*J. Gas Lighting*, cxxi, 33, 100, 181.)—*Knitting.*—The different kinds of web produced on the round knitting machine have the drawback of being less pliable than the ordinary web. Cotton mantles appreciably decrease in brilliancy after use, those of ramie are very constant, but the artificial silk mantles, now coming into use, combine the high and well-maintained illuminating power of ramie fibre with a great elasticity of the ash skeleton. Cuprammonium cellulose, chardonnet, and viscose silks are all used for the manufacture of mantles.

Washing.—Both cotton and ramie mantles require washing before impregnating, to remove the fat and mineral matter; this was done formerly by using a 3 to 5 per cent. solution of soda, followed by a 1 to 3 per cent. solution of hydrochloric acid. Recently, however, the process has been simplified; the mantles are soaked over night in a 2 per cent. solution of nitric acid and the next morning they are centrifuged, treated with a weak solution of ammonia, and then washed, first with condensed and afterward with pure distilled water.

Drying.—The mantles are dried in a current of hot air, and the imperfect ones sorted out. From this point scrupulous cleanliness in handling the mantles is imperative.

Impregnation.—The mantles are impregnated by being soaked in a 25 to 33 per cent. aqueous solution of thorium and cerium nitrates in the proportion of 99:1, to which very small amounts of beryllium and magnesium nitrates are added to harden and strengthen the ash skeleton. After soaking in this liquid for a time —from one to two minutes in the case of cotton or ramie mantles, and five hours for artificial silk mantles—they are passed through a wringing machine. The quantity of salts left in the mantles can be varied by adjusting the rollers of the wringer. The mantles are next dried at a temperature not exceeding 30° C.; the cotton and ramie mantles, cut in short lengths before impregnation, are stretched over glass cylinders, and the artificial silk mantles, impregnated in lengths, are run over wooden rollers. The upright mantles are then fitted with a tulle head sewn on, or with a patent head, and this is fixed by treatment with a 50 per cent. aqueous solution of aluminum and magnesium nitrates. Then the asbestos loop by which the mantles are suspended is sewn on. The inverted mantles are drawn together with impregnated cotton, to form the "spider," and are then fastened on to the supporting ring.

Burning Off.—If a trade-mark is desired on the mantle, this is stamped on with a solution of didymium nitrate, dissolved in a mixture of alcohol, distilled water, and glycerine, to which a little methyl Blue has been added. Then the mantle is shaped on a wooden shaper and is burned off. This is done with a Bunsen flame, beginning at the top of the mantle, and the mantle is hardened by increasing the pressure of the gas for a period of 1½ to 15 minutes.

The mantles now consist of a skeleton of ash and are ready for use, but they will not bear transportation. Therefore they are dipped in a collodionizing solution, consisting of 100 parts of 4 per cent. collodion solution, 40 parts ether, 6.5 parts camphor, and 3.5 parts castor oil. After rapid drying at a temperature of from 50° to 60° C., the mantles are trimmed to the proper length, sorted out into different qualities, and the imperfect ones rejected. Then follows a list of various defects to which mantles are liable, and the causes to which these defects may be attributed.

Vanadium-Aluminum Alloys. N. CZAKO. (*Comptes Rendus*, clvi, 140.)—M. Czako obtained alloys with 30 to 80 per cent. of vanadium by reducing vanadic acid with aluminum in crucibles lined with magnesia. Alloys with a lower percentage of vanadium have been obtained by melting these products with aluminum in suitable proportions. Micrographic study of the alloys suggests the existence of the compounds Al_3V, AlV, and AlV_2. The first two have been isolated from the alloys of which they formed the chief part by the regulated action of acids. It is as yet uncertain whether AlV_2 is a definite compound. With up to 10 per cent. of vanadium the alloys are still malleable. From 20 to 25 per cent. they may be pulverized in a mortar. Up to 53 per cent. they contain numerous cavities, which make it difficult to obtain a polished surface. The hardness increases with the percentage of vanadium up to 53 per cent., when it is between 6 and 7. With from 60 to 80 per cent. of vanadium the alloys are less hard and free from cavities.

Solubility of the Active Deposit of Thorium. C. F. HOGLEY. (*Phil. Mag.*, xxv, 330.)—The active deposit from thorium hydroxide contained in a metal dish was collected on a piece of platinum foil suspended over the dish and connected with the negative pole of a battery. The foil was then submitted to the action of the various solvents examined. Aqueous solutions of salts, hydroxides, and acids dissolved both thorium B and thorium C, but always a relatively larger amount of the former. The solubility in boiling water is small and slow; that in a boiling solution of potassium iodide is more than twice as rapid. Dilute acids, even cold, dissolve the deposit still more rapidly. Organic solvents dissolve at about the same rate as water, but chiefly thorium C. Thorium B is quite insoluble in chloroform and methylene iodide.

Ether Admitted Duty-free to Holland. ANON. (*Board of Trade J.*, Feb. 13, 1913.)—A Dutch royal decree, dated January 15, 1913, provides for the duty-free admission to the Netherlands, under certain conditions, of sulphuric ether required in factories or workshops as an aid for the preparation of iodoform gauze and iodoform cotton wool.

Micrographical Studies on Copper, Iron, and Steel. ANON. (*Atelier des Essais de métaux de la Cie. des Chemins de Fer. P. L. M.*)—(1) *Rapid estimation of arsenic in red copper.*—By etching the polished metal with pure nitric acid at 22° C. for five or six seconds, black spots are developed, the number of which, it is stated, bears a direct relation to the arsenic content of the metal. By comparing the metal under examination with a prepared scale of standard specimens of known arsenic content the percentage of arsenic present may be estimated to within about 0.06 per cent., as it is claimed. (2) *Cutting steel with the oxyacetylene blowpipe.*—When sheet or forged steel is cut by means of the oxyacetylene blowpipe, a zone of higher carburization is produced along the cut edges of the metal. Since in the cases examined the width of the zone was about 5 mm., it is considered that the edges of all plates, etc., so cut should be removed for a depth of 10 mm. to ensure the absence of affected metal from the finished articles. (3) *Effect of cold work on steel.*—It is found that the effect of cold work due to threading screws of large diameters is that the metal becomes much harder in the neighborhood of the thread than in the middle, to a depth of 3 or 4 mm.; the ferrite present in this zone was crushed and disseminated in fine needles. It is recommended that, after threading, all coupling-screws should be re-annealed at about 700° C. (4) *Adulteration of wrought iron* by the insertion of rolled cast steel in the "fagots" may be readily detected micrographically, the pearlitic zones being better defined and more marked when puddle steel has been introduced.

Kinetic Properties of a Molecule in a Substance. R. D. KLEEMAN. (*Phil. Mag.*, xxiv, 107.)—This is a further discussion of the question as to whether the kinetic energy of a molecule in a liquid is the same as that in a gas at the same temperature; the discussion is based on the hypotheses mentioned in a previous paper. It is concluded that the average velocity of a molecule in a liquid may be several times that corresponding to its temperature. A general formula is deduced for the coefficient of viscosity for matter of any density. General formulæ are also given for the coefficients of heat and of diffusion.

Australian Hard Wood. ANON. (*Amer. Mach.*, xxxviii, 3, 110.)—One of the most remarkable of the many valuable Australian hard woods is yate. Apparently this is the strongest timber known. Its average tensile strength is 24,000 pounds to the square inch, equalling that of good cast iron. Many specimens are much stronger, and one was tested up to 17½ tons per square inch, which is equal to the tensile strength of wrought iron. The tree grows to a maximum height of 100 feet, and sometimes attains a diameter of two and one-half or even three feet.

Mineral Oil Exports from the United States in 1912. ANON. (*Oil, Paint, and Drug Rep.*, Feb. 3, 1913.)—The exports of mineral oils from the principal customs districts of the United States in 1911 and 1912, which represent about 92 per cent. of the shipments from all ports, were as follows:

	1911		1912	
	GALLONS	AMOUNT	GALLONS	AMOUNT
Crude	184,984,498	$5,791,211	172,822,223	$6,373,771
Illuminating	1,108,333,605	60,857,290	1,023,681,414	61,918,491
Naphthas	131,286,657	10,988,213	175,089,771	19,365,132
Lubricating and paraffin	181,259,004	22,977,857	213,559,784	27,860,862
Residuum, gas and fuel oil	136,366,250	3,771,749	259,376,853	6,357,136

Filaments for Incandescence Electric Lamps. E. MORSAINT. (*French Pats. 446,140 and 446,310*, July, 1912.)—(1) Carborundum crystals are ground very fine, treated with *aqua regia* to remove metallic impurities, washed, dried, and formed into a paste with a carbonaceous binding material. The paste is formed into filaments, which are sprinkled with carbon to prevent adhesion, dried and heated in a closed chamber for four to five hours at a temperature of 600° C., after which the temperature is slowly raised to 1500° or 1600° C. The carbon is then burned off by heating the filaments to a red heat in dry air, and they are finally heated to 2000° C. in an electric furnace. It is claimed these filaments are not injured by excessive voltage. (2) Carborundum filaments prepared as above, but while still in the porous condition, are soaked in a liquid, such as collodion, containing finely-divided silicon in suspension. The liquid must be such that no trace of free carbon is left in the filament after it has been exposed to a red heat in a very slightly oxidizing atmosphere. After removing the free carbon the filaments are heated for two or three hours to 2000° C. in an electric furnace, whereby a filament composed of a crystalline aggregate of pure carborundum and silicon is obtained.

Suction between Vessels. A. H. GIBSON and J. H. THOMPSON. (*Engineer*, cxiv, 313.)—The following experiments were conducted on the Firth of Tay to obtain some information as to the magnitude and range of action of the forces involved in the case of "suction" or interaction between passing vessels. Two screw-propellers were used—the *Princess Louise*, 88.5 feet long, 13 feet beam, 5.66 feet mean draught, about 96 tons displacement, and a motor-launch 29.33 feet long and 6.75 feet beam. Two sets of experiments were carried out. In the first the vessels were manœuvred until on sensibly parallel courses, heading for the same distant object, their lateral distances apart and speeds being

varied in different trials. Their courses having been satisfactorily fixed with the helm of the motor boat amidships, this helm was lashed, the helm of the *Princess Louise* being later manipulated so as to keep her on her original course. The second series of experiments was carried out with the view of measuring the helm angle required to maintain the course of the smaller vessel when in the vicinity of the larger one. In these experiments the relative positions of the two boats were obtained as in the first set, the helm being adjusted as required to keep the head of the vessel on its original course. Full details are given and diagrams showing the relative paths and positions of the two vessels under varying speeds and in different relative positions. The general conclusions deduced are: The greater the difference between the speeds of the vessels, the smaller is the risk of collision, since such a difference reduces the time during which the mutual forces are operative, such an effect being much more marked when the smaller vessel is the faster. But if the larger vessel is the faster, and particularly if her speed is accelerated while passing the smaller, the attractive forces are increased to an extent which partially, and in some cases entirely, counterbalances the effect of the reduction of the time during which the vessels are in dangerous proximity. Hence any attempt of the larger vessel to draw ahead of the smaller greatly increases the risk of collision. The results of the trials show that, under favorable circumstances, interaction is a very real danger to navigation, even in deep and open water. With vessels of the relative sizes adopted for the experiments, if the possibility of interaction is realized from the very first, and if all initial swerve is prevented by an early application of the helm, there would appear to be little danger even at lateral distances so small as one-half the length of the smaller vessel; but if this possibility be not realized, and such a swerve has once started, a much greater helm angle is necessary to control the vessel, and, failing *immediate control,* collision occurs within comparatively few seconds even from astonishingly great distances. The importance of this fact is more readily grasped when it is realized that with a vessel, say, 300 feet in length, passing a vessel, say, 900 feet in length, the forces of interaction have to be reckoned with even when the vessels are 1000 feet apart laterally, a distance which would ordinarily be considered to be giving the larger vessel a very wide and safe berth.

Molybdenum in the Liege Coal-pits. A. JORISSEN. (*Bull. Soc. Chim. Belge,* xxvii, 21.)—Molybdenum is detected in the soot and ashes from Liège coal; in some cases molybdenum compounds may be extracted from the soot or ash by water. The red-colored heaps of débris resulting from the slow combustion of the coal contain appreciable quantities of molybdenum, which appears to be distributed throughout the coal fields. Coal from the Charleroi mines also contains molybdenum.

New Sources of Wood Oil. (*U. S. Cons. Report, Ch. of Comm. J.*, Feb., 1913.)—Wood oil is produced from the nuts of the "tungshu" tree (*Aleurites fordii*) of China, and practically the entire supply comes from that country. Its normal price is 2s. 6d. (60 cents) per gallon, and in the fiscal year ending June 30, 1911, the United States imported 5,000,000 gallons. The wood oil tree will grow along the Pacific coast, south of Sacramento, and in the Gulf States. There are no groves of these trees in the United States from which data as to the commercial production can be obtained. Another source of supply is the Kukui nut or candlenut, which grows in Hawaii and the Philippines. If the nuts can be gathered and the oil extracted profitably, this oil should compete with Chinese wood oil.

Blast-Roasting of Sulphide Ores. J. H. LEVINGS. (*Inst. Min. and Met.*, Jan. 16, 1913.)—Since 1900 satisfactory results were obtained from the Huntington-Heberlein process at Zeehan, Tasmania, where it was first used outside of Europe. The ores contained lead and zinc. It was found that coarser limestone up to 12 mm. size could be used without harm, and further experiments with the Carmichael-Bradford process showed that iron and manganese oxides could be substituted for limestone with equally good results. Roasting was done by lighting a fire in the pot and then filling with the mixture of ironstone and ore. It is advantageous to give a preliminary roasting in mechanical furnaces before pot-roasting with ores containing much over 10 per cent. of sulphur. The constituents of the ore mixture should be in the approximately correct proportions to form a slag. The shape of the pot exerts a marked influence on the process. At another plant attempts to roast an ore consisting mainly of iron pyrites in silicious gangue, which contained 31 per cent. of sulphur, were made after mixing the ore with 15 per cent. of iron and manganese oxides. The Mount Lyell type of pot worked well, while in the Huntington-Heberlein pots very poor results were obtained, the product being soft with much "fines," and contained 16.5 per cent. of sulphur; while the Mount Lyell pots yielded an almost solid cake, with an average sulphur content of 8 per cent. It required 12 hours to finish a six-ton charge.

Dynamo Sheet Steel. U. S. PATENT 1,033,352. (*Met. and Chem. Eng.*, x, 563.)—This patent of W. Rübel states that dynamo sheet steel should be free from manganese, silicon, and phosphorus, whilst a slight contamination with carbon and sulphur is less injurious. The addition of spiegeleisen during refining should therefore be avoided, whilst copper, from one to three per cent., is added to the steel to act as a deoxidizer. The refining is done first in a basic and then in an acid converter, or it may be done in the reverse order, or in an electric furnace.

Theory of Absorption and Scattering of α-Rays. C. G. DARWIN. (*Phil. Mag.*, xxiii, 901.)—The α particles from radioactive substances have been thoroughly investigated so that the main features of their motion are now well known. On account of their great mass they go straight, or nearly straight, through matter until their energy is exhausted, the ionization produced being proportional to their loss of energy. It is therefore necessary to adopt a structure for matter such that the α particle pulls electrons out of the atoms containing them, and in so doing loses velocity. The author takes the atomic structure proposed by Rutherford. This considers the atom to consist of a cluster of electrons held by an unknown field of forces round a central charge, which latter is of such amount as to neutralize them and which is supposed to be the seat of the mass of the atom. It is assumed that the electrons in the atom act on the α particle with the ordinary law of inverse-square, and in considering the motion of an α particle the effects of the perturbation of the electron by the rest of the atom are neglected. An equation is deduced relating the velocity of α particles to the distance they have travelled from their source, and this "velocity curve" agrees closely with the experimental curve of Geiger. From the equations the number of electrons in the atom is calculated and found to be intermediate between the atomic weight and its half. The atomic radii are found to decrease with increasing atomic weight. The numbers obtained from the consideration of the absorption of α particles are applied to scattering, and give results in all cases in good agreement with experimental measurements.

Method of Measuring the Speed of Light. C. FÉRY. (*Comptes Rendus*, clv, 823.)—To avoid the difficulty of evaluating the angular velocity of the ordinary rotating mirror in the determination of the speed of light, there is suggested the substitution of a mirror carried on the end of one prong of a tuning-fork. Light from a source at one side is directed on to a screen by a plane plate at an angle of 45°. Through a slit in the screen light passes to the mirror on the fork, and back through the slit to a distant mirror, and then returns. Then when the fork is vibrated the original beam gives two displaced images, A, A', of the slit on the screen, due to the full motion of the prong. But two other images, a, a', at a less distance apart are also obtained, which are due to the slightly displaced positions of the prong when the light has returned from the distant mirror. Thus if the time occupied by the double journey is t, and the period of the fork T, we have $\sin 2\pi t/T = a\,a'/A\,A'$. Thus for a double distance of 30 k. m. and $T = 0.002$ second, $t = 0.0001$, $a\,a'/A\,A' = \text{Sin } 18° = 0.31$. So if $A\,A'$ were 20 mm., $a\,a'$ would be of the order of 6 mm. The two pair of images could be photographed simultaneously, and thus considerable accuracy would be obtained.

Mill Scale as a Cause of Pitting of Steel Pipes. G. C. and M. C. WHIPPLE. (*Eng. News,* lxviii, 856.)—It is known that accelerated corrosion tests of iron and steel by exposure to strong acids are of small value as an indication of their probable behavior in actual service. Steel pipe-lines usually fail on account of pitting, which ultimately leads to holes and leaks. Mill scale is an important factor in pitting, as is shown by the fact that steel plates which corrode badly when this scale is left on do not pit seriously after the scale is removed. Galvanic survey of the mill scale gives materially different results for wrought iron and for steel, and indicates a much greater homogeneity of the wrought-iron scale. Electrolysis tests show that wrought iron has a less tendency to pit than steel. Copper steels corrode much more slowly than ordinary steels in strong acids, but behave very similarly in water. Since copper does not change the electrical conditions of the scale, it does not affect the tendency to pit. Protection against pitting is best attained by the removal of the scale, but, since this is an expensive process, it appears that efforts should be made to decrease the scale during manufacture, or make it more easily removable, so as to improve its electrical condition.

The Chromium Red Glaze. C. E. RAMSDEN. (*Trans. Eng. Ceram. Soc.,* xi, 196.)—The glazes used were wholly fritted in order to avoid decomposition of the stain in the further fire. The author agrees with all the other investigators except Purdy, that the source of the chromium does not affect the tint. The formula CaO, SnO_2, 0.024 Cr_2O_3, is given for the stain before calcination. If much more chromium is introduced, darker colors are obtained through the formation of insoluble chromates which are not removed in washing. Lime is essential to the production of a good crimson glaze. Magnesia and baryta turn it green and steel-gray respectively. The tint of the calcined powder is not an indication of the color of the resultant glaze. Lead oxide in the glaze is essential for crimson. Silica preserves the red tint under the glaze, while alkalies make it lilac. Borates have but slight influence.

Natural and Magnetic Rotatory Dispersion. T. M. LOWRY. (*Roy. Soc. Phil. Trans.,* ccxii, 261.)—This article treats of: (1) A new test for the optical purity of quartz. (2) An accurate determination of the rotatory dispersive power of quartz for 24 wavelengths in the visible spectrum. (3) Experiments to test Wiedemann's law. It was found that this law holds good for quartz but not for optically-active liquids.

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